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The relief features of Ohio; F. Carney. 13 pp., 1 fig.
Geographic conditions in the early history of the Ohio country; F. Carney. 20 pp.

SOME PROPARIA FROM THE ST. CLAIR LIMESTONE, ARKANSAS

NORMAN L. THOMAS[1]

Received April 30, 1929; published August 31, 1929

STRATIGRAPHY

The St. Clair Limestone is a Silurian limestone which outcrops on the south flank of the Ozark Uplift near the city of Batesville, in north-central Arkansas. This formation has a maximum thickness of over 100 feet at St. Clair Spring and at Cason Mine, but it thins in an irregular fashion westward toward the White River, forming a narrow, broken chain of outcrops from the Spring, six miles northeast of Batesville, to Williamson, seventeen miles northwest of Batesville. The irregularity in thickness is not due to differential deposition but rather is due to the great erosional unconformity which was made by erosion stripping away most of this Silurian limestone from the district and leaving only a few scattered remnants in the eastern part and a continuous but thin out crop along the White River. There is also an obscure unconformity at the base of the St. Clair Limestone. The formation is a crystalline limestone of medium texture, colored by pink and white calcite crystals.

The columnar section for Independence County is as follows:

Mississippian	Batesville sandstone
	Moorefield shale
	Boone chert
Devonian	Chattanooga shale
	Penters chert
Silurian	Lafferty limestone
	ST. CLAIR LIMESTONE
	Brassfield limestone

[1] *Published with permission of Chief Geologist of Pure Oil Company.*

Ordovician	Cason shale
	Fernvale limestone
	Kimmswick limestone
	Joachim limestone
	St. Peter sandstone
	Magnesian limestone and sandstone

Manganese is being mined from the Cason Shale at various points and interesting specimens of fossils replaced by the ore minerals have been found. Limestone, for building purposes, and phosphate, for fertilizer, are the only other economic resources which are being exploited at the present time in the St. Clair district.

The St. Clair Limestone is the only formation in the district which is predominantly fossiliferous, and it is of special interest because of the variety and the abundance of the fossil forms and the comparisons which may be made between these forms and specimens from other Silurian formations around the Ozark Uplift, the Chicago and New York areas, the Wenlock Limestone of England, the Leptaena Limestone of Sweden, and Barrande's Etage E of Bohemia.

THE FAUNA

Phyla represented:

Porifera	Corals; a few horn-shaped.
Echinodermata	Crinoids; few.
Molluscoidea	Bryozoan; one genus noted.
	Brachiopods; many species, many specimens. Few Neotremata, majority Protremata, many Telotremata.
Mollusca	Pelecypod; one genus.
	Gastropods; straight and coiled.
Arthropoda	Trilobites; abundant in species and specimens, mainly Opisthoparia and Proparia.

The lower St. Clair Limestone is characterized by its dwarf fauna and the abundance of specimens belonging to the genera Merista and Nucleospira. There is a thin stratum a little higher that is characterized by Delthyrid shells. The whole formation has a dwarf fauna, but the upper two-thirds contains larger forms of trilobites, cephalopds and brachiopods. Trilobites are most

abundant in the number of individuals, and brachiopods are most abundant in the number of species. For local field identification the following fossils have been found to be the most useful:

Staurocephalus murchisoni
Dalmanites arkansana
Spirifer radiatus
Dicranopeltis arkansana
Illaenoides elongata
Merista parva
Nucleospira clairensis

FOSSIL DESCRIPTIONS

CALYMENE, Brongniart, 1822

"Complete body sub-oval in outline, possessing the power of complete enrollment; cephalon sub-crescentiform with thickened margin, genal angles usually rounded; glabella strongly convex, narrowed in front, with three pairs of deep lateral furrows; the occipital segment well defined; posterior limbs of facial sutures originating just in front of the genal angles; free cheeks elongate, separate, usually with a free plate between their anterior extremities in front of the glabella; eyes small; hypostome subquadrate, notched. *Thorax* with thirteen segments, the axis strongly convex and bounded by deep axial furrows; pleural lobes wider than the axis, bent down laterally. *Pygidium* distinctly marked off from the thorax, with six to eleven segments, the axis prominent and the margin entire."[2]

CALYMENE ALTIROSTRIS, Foerste

Plate IX, figs. 1,2

Sub-ovate in outline, distinctly trilobate, widest along occipital furrow, narrowing gradually toward pygidium, then narrowing much more rapidly and ending in a rather blunt obtuse angle. *Cephalon* short, broad, the width being roughly twice the length. Glabella strongly convex, elevated above cheeks, and descending

[2] Weller, Stuart. Bull. Chicago Acad. Sci., 4, 260–1 (1907).

perpendicularly in front to a well-marked and fairly wide, flat, frontal margin. Deep dorsal furrows connecting with broad, rounded occipital furrow. Frontal lobe sub-quadrate with a length equal to about one fifth the length of the glabella. First pair of lateral lobes merely nodes on flanks of glabella. Second pair sub-quadrate and much larger. Third pair large, sub-triangular, rounded convex areas coalescing with the median lobe. First pair lateral furrows short and shallow, and directed very slightly backward. Second pair of lateral furrows deep but short, pointing obliquely backward. Third pair have marked backward trend ending in a well rounded pit-like depression, or in a slight bifurcation with the longer branch extending backward toward the occipital furrow. The lateral furrows do not make impressions crossing the glabella. Occipital furrows broad, rounded, and arched, slightly shorter than marginal furrow behind the cheeks. Occipital ring arched and convex. Cheeks rounded and sloping abruptly to anterior margin and more gently to lateral margins. Eyes opposite second lateral furrows. Facial suture extends almost parallel to axis from frontal margin, curves behind eye, and makes a convex curve from the eye to the rounded genal angle. *Thorax* unknown. *Pygidium* associated with the head described and probably belonging to the same species, sub-pentagonal, convex, well divided into three distinct lobes having 5 to 7 segments, the last one generally quite indistinct. The middle lobe higher than the pleura, tapering to rounded point nearly to the end of the pygidium. Pleural lobes slightly greater in area than axial lobe. They show all the segments extending to the edge more clearly in casts than on the surface. Posterior angle very obtuse.

Measurements on two cephalons and two pygidia:

	mm.	mm.
Length of cephalon	29	14
Width of cephalon	59	24
Length of pygidium	17	24
Width of pygidium	27	37

Remarks.—This trilobite is rather rare in the St. Clair Limestone, the pygidium being found occasionally and the complete

cephalon very rarely. It is characterized by the steep frontal slope, the wide flat frontal border of cephalon and the blunt posterior end of the pygidium. This is probably the same form that Gilbert Van Ingen mentions as *Calymene altirostris*,[3] and that was later described by A. F. Foerste.[4]

CHEIRURUS, Beyrich

Genotype: *Cheirurus insignis*, Beyrich

"Cheirurid of medium size. Cephalon roughly semi-circular in general outline, genal angles produced into spines; glabella large, constituting more than one-third of the cephalon, expanding forward, moderately convex; the three pairs of glabellar furrows distinct, sloping gently backward, the posterior pair straight and opening directly into the neck furrow at or near the middle of the glabella, and isolating triangular basal lobes; eyes in the center of the cheeks; cheeks pitted, glabella smooth.

"*Thorax* of eleven segments; the axial lobe slightly less than one-third the width of the thorax and tapering gently backward; each pleuron divided by a node-like constriction into a large inner third and a smaller outer two-thirds; the inner third cut by a deeply impressed diagonal furrow.

"*Pygidium* composed of three segments with or without a rudimentary fourth segment; pleura produced into sub-equal, radiating spines, anterior pleura similar to thoracic pleura.

"Hypostoma sub-quadrate in general outline, very slightly wider at the anterior than at the posterior; anterior edge flatly convex, posterior edge fairly straight or faintly concave; central axis faintly constricted well toward the posterior.

"Range: Upper Ordovician to Upper Silurian.

"Distribution: Europe, North America, Central Himalayas."[5]

[3] Van Ingen, Gilbert. School of Mines Quarterly, 23, 35 (1901).

[4] Foerste, A. F. Jour. Sci. Lab. Denison Univ., 20, 110, (1923).

[5] Barton, D. C. A Revision of the Cheirurinae. Wash. Univ. Studies, 3, Pt. I, (1915).

CHEIRURUS NIAGARENSIS, Hall

Plate IX, figs. 3–7

Cephalon semi-circular in outline, gently convex. The glabella is the highest, most convex, and most prominent part of the head and from this the cheeks slope away. The glabella expands toward the front and reaches the front of the cranium. It is widest at the middle of the frontal lobe. Granulose. Dorsal furrows are narrow, concave laterally, but not deep. The first pair of furrows sharp and rather short, extending only a little distance into the glabella, usually bent a little forward. Second pair almost at right angles to the axis. Posterior furrows extend diagonally from the dorsal furrows and unite with each other at the occipital furrow on the axis. Eyes opposite the second pair of glabellar furrows. Fixed cheek pitted. There is a distinct furrow and margin around the body portion except in front of the glabella. The genal spines rather long. *Hypostoma* associated with these cephalons of *niagarensis*, and probably belonging to that species, roughly tetragonal; the posterior margin nearly straight, the anterior rounded, no spines, but surface covered with sharp pustules. There is a wide furrow around the rounded wedge like convex part of the hypostoma.[6]

Pygidium not found attached to thoracic segments and cephalon; a type present resembles in most respects these attributed to *Cheirurus niagarensis*. Composed of three segments and one posterior rudimentary segment. Pleura produced into subequal radiating spines. The last pair extend farther back than the other two. A very short median spine is present. Prominent pit in the axial furrow between segments. Axial lobe cone shaped pointing back.

Remarks.—The specimens found in the St. Clair Limestone correspond quite closely in proportions and outline to Hall's figure, which has been selected by Raymond as the type for this species.[7] The eyes may be slightly farther from the glabella than

[6] Hall, James. Paleon. N. Y., 2, pl. 67, fig. 10 (1852).

[7] Raymond, Perry E. New and Old Silurian Trilobites. Bull. Mus. Comp. Zool., Harvard Univ., 60, 30–4, pl. 4, (1916).

in Raymond's description, the glabellar furrows are a little longer, and the genal spines may diverge slightly more. The ratio of the width of the frontal lobe to the width of glabella is 0.45, while Hall's is also 0.45; ratio of length of frontal lobe to length of glabella 0.53, Hall's 0.60; ratio of width of posterior lobe to frontal lobe 0.73, Hall's 0.83. These are averages for a number of specimens, but there was little variation among the St. Clair Cheiruridae.

DEIPHON, Barrande

"Cheeks of the head reduced to elongate, recurved, spine-like processes; glabella sub-globular, comprised largely of the frontal lobe which is greatly produced anteriorly, the lateral furrows nearly or quite obsolete; free cheeks minute, eyes small, occupying the angle between the spine-like fixed cheeks and the glabella. Thorax with nine segments with free spiniform pleura. Pygidium short, with two pairs of lateral, curved, spiniform processes."[8]

DEIPHON FORBESI, Barrande

Plate IX, figs. 8, 9

Cephalon characterized by a spheroidal glabella on the sides of which the lateral lobes and furrows are reduced to a rudimentary state, and the cheeks form spine like processes. *Glabella* is produced anteriorly with the globular frontal lobe larger than the rest of the cephalon and extending beyond the frontal margin by two-thirds its length. Occipital furrow is quite broad and deeply rounded, and is marked at each extremity by an oval pit-like depression which may be the remains of a pair of lateral furrows just back of the frontal lobe. The occipital ring is narrow and arched transversely. Cheeks are reduced to a pair of elongate, curved, spine-like processes which extend obliquely forward from the posterior and posterior-lateral flank of the frontal lobe and from the occipital furrow and ring. They curve outward and forward a third of their length, and then recurve backward with a gentle flexure. Eyes are relatively large

[8] Weller, Stuart. Bull. Chicago Acad. Sci., 4, 268 (1907).

hemi-domes, raised, and directed forward and outward, situated on either side of the glabella in the triangular fixed cheeks practically in the rounded angles between the bases of the cheek spines and the edge of the glabellar lobe. A small spine extends forward from the frontal border of the fixed cheek at about a third of the distance from the eye to the end of the cheek spine. The whole surface, with the exception of the occipital furrow, is covered with large granulations interspersed with small granules scattered in irregular arrangement. Smaller granulation-facets on the eyes.

Measurements of three cephalons:

	mm.	*mm.*	*mm.*
Length cephalon (along axis)	7	7	
Greatest width	19		
Distance between eyes	6	6	5
Distance between front spines	11		9
Length spheroidal segment	6	6	4
Width spheroidal segment	5	5	3.8

Pygidium and *thorax* have been found elsewhere and are well described by Salter.[9]

Remarks.—Salter notes that the glabella is "rather quadrate in age, but truly hemispheric in junior stages, or rather subspherical, for it forms at least three quarters of a sphere, and in front it is only somewhat less convex beneath than on the dorsal surface."[10] The cheeks "arch upward more in young specimens, so as to be like the figures given by Barrande;[11] but are more horizontal at their origin in the adult."

This species differs from *Deiphon americanus* (Weller) in the more marked anterior position of the bases of the cheek spines, and in the greater rounding of the flexure of the cheek spines, and in the presence of the secondary anterior spine on the front edge of the fixed cheeks.[12] The St. Clair specimens resemble *americanus* in the presence of the "pit furrows" and in the wide occipital furrow. The general shape of the cephalon, the curva-

[9] Salter, J. W. British Trilobites. 88, pl. VII (1864).
[10] Salter, *ibid.*
[11] Barrande, J. System. Silur. Bohem. 814–6, pl. 39, fig. 50–55 (1852).
[12] Weller, Stuart. Bull. Chicago Acad. Sci., 4, 268–9, pl. XXIV (1907).

ture of the cheeks, the presence of an anterior spine on each cheek resembles *forbesi*. The position of the base of the cheek spine is intermediate between *americanus*, where it is quite posterior on the glabella, and *forbesi*, where it is nearly opposite the middle of glabella. This may be a new species, but the characters are so near those of *forbesi* that it seems best to refer it to that species even though *forbesi* is European.

STAUROCEPHALUS, Barrande, 1846

"Complete body sub-ovate in outline. *Cephalon* with a conspicuous globular anterior glabellar lobe produced entirely beyond the frontal margin of the head, the lateral glabellar lobes reduced in size; cheeks of moderate size, convex, with short genal spines; eyes small. Thorax strongly trilobed, with ten segments. *Pygidium* small, with three pairs of pleural segments which are produced distally in backwardly pointing free points."[13]

STAUROCEPHALUS MURCHISONI, Barrande

Plate X, figs. 10, 11

The trilobite is oval in shape with a globular frontal lobe extending beyond the main part of the cephalon. *Cephalon*, exclusive of the globular anterior extension, is roughly semi-circular in outline. The two opposite posterior-lateral angles are extended into short genal spines. The head may be characterized as a cross formed of four inflated parts, viz., the large subspherical frontal lobe, and the cylindrical part containing the almost obsolete glabellar lobes, together forming the glabella, which is separated by deep dorsal furrows from the inflated sub-triangular areas on either side which form the cheeks and complete the cross. First pair of lateral furrows, deep, rounded, extend across glabella separating the globular frontal lobe from the cylindrical median lobe. Second and third pair of lateral lobes merely two pairs of pit-like depressions on the flanks of the axial lobe, the second pair well forward, and the third pair near the middle, both being well down the flanks almost in the dorsal furrow.

[13] Weller, *ibid.* 269–70.

The cheeks are sub-triangular in outline and dome-like in relief, the eyes are located near the top and slightly on the outside on the convexity. Facial sutures are shown on a few specimens. They extend from the outer frontal lobe to the eye and thence toward the postero-lateral angles. In front the surface of the cheeks drop away nearly perpendicularly to the frontal and lateral margins which are rather broad and are fringed by approximately twelve escallop-like spines. Occipital furrow shallow and rounded in the bottom. Occipital ring narrow and arched transversely, *i.e.*, lengthwise of the ring. The surface of the cephalon is covered with various sized granulations, and these, with the short slender genal spines and escallop-like spines on the margins, make up the distinctive ornamentation. *Thorax* and *Pygidium* not noted in St. Clair Limestone.

Measurements of two specimens:

	mm.	*mm.*
Length of cephalon along median line	10	5
Length of frontal lobe	5.5	2.5
Width head—along occipital segment	13	5.5
Distance between eyes	6.5	3

Remarks.—This species corresponds very closely to *Staurocephalus murchisoni* as described by Barrande, and Salter as cited above. Most of the St. Clair forms are smaller, and the cheeks extend farther along the globular frontal lobe, but they do not differ noticeably in other respects. The posterior margin is straighter than that of *obsoleta* Weller and the cheeks and axial lobe are less sharply elevated. Species *murchisoni* is a very characteristic form in the St. Clair Limestone and is very abundant.

DALMANITES, Emmrich, 1845

"Entire body sub-oval in outline, generally angular posteriorly. *Cephalon* sub-crescentiform, the genal angles usually produced into spines; glabella prominent, broadest in front, with three pairs of well-marked lateral furrows; cheeks large with clearly defined facial sutures; eyes large and prominent, coarsely faceted. *Thorax* with eleven segments, axial furrows well-defined, axis

strongly convex and narrower than pleural lobes. *Pygidium* large, usually sub-triangular, the posterior extremity frequently pointed or mucronate; axis prominent with numerous segments."[14]

DALMANITES ARKANSANA, Van Ingen, 1901

Plate X, figs. 12–14

Cephalon, sub-triangular, bluntly rounded in front; lateral margins curving gently backward and outward to the genal spines; moderately convex but flattened on the glabella between the eyes. Glabella sub-pentagonal, reaching front of cephalon, something like a keystone in shape, broadest across the middle of frontal lobe, narrowing forward to rounded point and narrowing backward to slightly less than half the greatest width at occipital furrow. Dorsal furrows well marked but not deeply indented. First pair lateral furrows broad, rounded, opposite front of eyes, extending two-thirds the distance to axis, bent obliquely inward and backward. Second pair much shorter and nearly normal to the axis, reaching about two-thirds the distance from dorsal furrows to axis, deeply cut in inner half and becoming faint toward dorsal furrows. Third pair opposite back of eye, slightly shorter than second, curves slightly forward near dorsal furrow. None of the glabellar furrows join across the median portion of the glabella, the width of the unfurrowed median portion about one-third the width of the posterior part of the glabella. Frontal lobe large, sub-quadrate, first lobe made up of two sub-triangular segments which coalesce along the axis; second sub-quadrate, smaller than first, third lateral lobe smallest. Occipital furrow behind glabella, marginal furrow wider back of cheeks. Cheeks large, sub-triangular, sloping outward and downward convexly to border; genal angles produced into short spines. Eyes large, close to dorsal furrow, and opposite first and second lateral glabellar lobes; palpebral lobes elevated almost to the height of the glabella.[15] *Thorax* not recognized. *Pygidium* sub-triangular; posterior extremity blunt, obtuse angle without caudal spine.

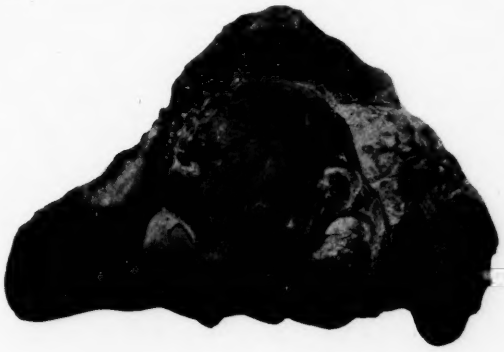
[14] Weller, *ibid.* 272.

[15] Van Ingen, Gilbert. School of Mines Quarterly, 23, 70–3 (1901).

Plate X, figs. 16 and 17 show two cephalons of larger size possibly belonging to another species. There is a suggestion that the cephalon changes with an increase in size by a rounding of the frontal spine and a broadening and flattening of the frontal lobe and cheeks and a reduction of the slope to the frontal margins and also a flattening of the margins. The three specimens illustrated show these characters which may be due to increase in size or to the presence of another distinct species. The medium and large cephalons are not described here and are merely ilustrated pending further study. A very complete series of varying sizes should be collected before the species are described or all are grouped under one name.

PLATE IX

1. *Calymene altirostris* Foerste. Cephalon.
2. *Calymene altirostris* Foerste. Pygidium.
3. *Cheirurus niagarensis* Hall. Cephalon.
4. *Cheirurus niagarensis* Hall. Cephalon.
5. *Cheirurus niagarensis* Hall. Pygidium.
6. *Cheirurus niagarensis* Hall. Pygidium.
7. *Cheirurus niagarensis* Hall. Hypostoma.
8. *Deiphon forbesi* Barrande. Cephalon.
9. *Deiphon forbesi* Barrande. Cephalon.



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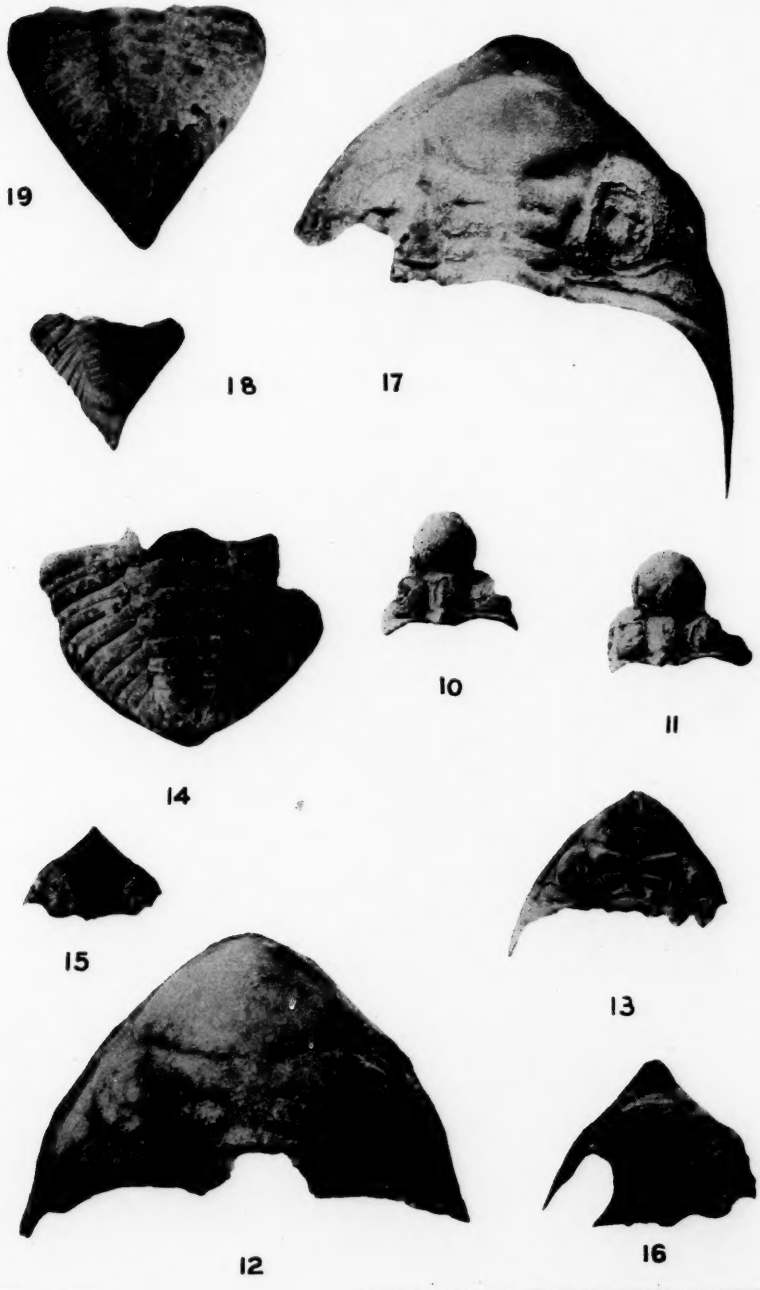
5

NORMAN L. THOMAS

PROPARIA FROM ST. CLAIR LIMESTONE, ARKANSAS

PLATE X

10. *Staurocephalus murchisoni* Barrande. Cephalon.
11. *Staurocephalus murchisoni* Barrande. Cephalon.
12. *Dalmanites arkansana* Van Ingen. Cephalon.
13. *Dalmanites arkansana* Van Ingen. Cephalon.
14. *Dalmanites arkansana* Van Ingen. Pygidium.
15. *Dalmanites cf. vigilans* Hall. Small cephalon.
16. *Dalmanites sp.* Medium cephalon.
17. *Dalmanites sp.* Large cephalon.
18. *Dalmanites cf. vigilans* Pygidium
19. *Dalmanites cf. vigilans* Hall. Pygidium.



NORMAN L. THOMAS

PROPARIA FROM ST. CLAIR LIMESTONE, ARKANSAS

THE CEPHALOPODS OF THE RED RIVER FORMATION OF SOUTHERN MANITOBA

AUG. F. FOERSTE

Received July 8, 1929; published August 31, 1929

The presence of strata of Ordovician age in those parts of southern Manitoba dominated by Lake Winnipeg and the drainage area of Red River has long been known. The upper division of these strata, now known as the Stony Mountain member of the Richmond group, was correlated by J. F. Whiteaves in 1880 "with the well known rocks of the Hudson River or Cincinnati group of southern Ohio and elsewhere." Recently, in his Geology of Anticosti, W. H. Twenhofel correlated the Stony Mountain formation more definitely with zones 3, 4, and 5 of the Vaureal member of the Richmond group as exposed on Anticosti island; the Vaureal as a whole he correlated with that part of the Richmond group in Ohio which overlies the Waynesville, extending from the Liberty to the Elkhorn. Regarding Stony Mountain he stated that this outlier, somewhat isolated, forms a hill some 50 feet in height on the west bank of Red River not far from Fort Garry. In its lower part it consists of limestones with clayey partings which, toward the summit, pass into rich cream-coloured, yellow or greyish white dolomites, the whole having a horizontal attitude. These strata contain 53 identified species, of which 33 species occur also in the Richmond of Anticosti, 22 being considered index fossils to the Richmond. The occurrence of these fossils at Stony Mountain suggested to Twenhofel a line of open water from Anticosti to Stony Mountain, and the direction of their probable migration as being from the former to the latter place.

In 1895, D. B. Dowling subdivided the Ordovician strata

underlying the Stony Mountain formation into the following members, named in descending order:

Upper Mottled limestones,
Cat Heat limestones,
Lower Mottled limestones,
Winnipeg sandstones.

In 1928, the present writer proposed the terms Selkirk limestone and Dog Head limestone for the first and third divisions of the preceding series, and used the term Red River formation to include the first three, resulting in the following list, also in descending order:

		Feet
Stony Mountain formation		100+
Red River formation	Selkirk limestone	130
	Cat Head limestone	70
	Dog Head limestone	70
Winnipeg sandstone		100+

In 1892, J. B. Tyrrell correlated the strata here included in the Red River formation with the Trenton, and the Winnipeg sandstone with the Chazy (St. Peter) sandstone. In 1897, J. F. Whiteaves stated that the limestones here included in the Red River formation "most probably represent the whole of the Utica and Trenton formations, inclusive of the Galena, though they hold several fossils elsewhere supposed to be restricted to the Hudson River (Cincinnatian?) group." No fossils had been found in the Winnipeg sandstone, except at their summit, in passage beds immediately beneath the Red River formation, consisting of a few feet of strata referred to the Black River and Birdseye (Lowville).

In 1897 J. F. Whiteaves brought together all the information at that time known regarding the fauna of the Red River formation. The resulting list of species was republished, with additions, by Dowling in 1900, in his *Report on the geology of the west shore and islands of Lake Winnipeg*, in the form of a table, in which the horizons for the individual species are indicated. This report by Dowling is at present the chief source of information regarding the vertical distribution of fossils within the Red

River formation. Since this report is accessible to but few geologists, and has long been out of print, the list of species there given, with the exception of the cephalopods, is reprinted here. In this list the nomenclature employed by Dowling is retained. Recent changes in nomenclature may easily be looked up in Bassler's Bibliographical Index of American Ordovician and Silurian Fossils. The cephalopods, being the special subject of the present paper, are listed separately on a later page.

In this list the horizons are indicated by letters, as follows: Winnipeg sandstone (W), Dog Head limestone (D), Cat Head limestone (C), Selkirk limestone (S), and Stony Mountain formation (St). Species originally described from southern Manitoba are printed in italics.

ORDOVICIAN FOSSILS OF SOUTHERN MANITOBA

*Lichrophycus ottawaensis	W
Chondrites (Bythotrephis) patulus	C
Chondrites (Bythotrephis) cuneatus	C
Chondrites cupressinus	C
Chondrites gracillimus	C
*Bythotrephis cf. succulens	St
*Receptaculites oweni	D, S
*Ischadites iowensis	S
†Pasceolus gregarius	D, C, S
Aulocopella winnipegensis	C
Trichospongia hystrix	C
*Climacograptus bicornis	D
Thamnograptus affinis	C
Inocaulis canadensis	C, S
†Halysites catenularia gracilis	D, C, S
Tetradium fibratum	S
Columnaria alveolata	D, S
†*Diphyphyllum stokesi*	S
Streptelasma robustum	D, S
Streptelasma rusticum	St
Streptelasma trilobatum	St
Protaraea vetusta	D, St
Protaraea magna	D, C
†Favosites prolificus	S, St
Calapoecia canadensis	D, S, St
Beatricea undulata	St
Beatricea nodulosa	St
Solenopora compacta	D

Chaetetes perantiquus	D
*Glyptocrinus ramulosus	St
Glyptocrinus sp.	W, D, C
Taeniaster sp.	C
*Serpulites dissolutus	W, D
Arabellites sp.	D
*Rhinidictya mutabilis	W
Rhinidictya obliqua	W
*Escharopora ramosa	W
Stomatopora canadensis	D
Proboscina auloporoides	St
Proboscina frondosa	St
Monticulipora parasitica plana	St
Homotrypella gracilis	St
Bythopora delicatula	St
Bythopora striata	St
Petigopora scabiosa	St
Monotrypella quadrata	St
Batostoma manitobense	St
Arthroclema angulare	St
Helopora harrisi	St
Sceptropora facula	St
Ptilodictya whiteavesi	St
Dicranopora fragilis	St
Dicranopora emacerata	St
Goniotrypa bilateralis	St
Pachydictya hexagonalis	St
**Pachydictya magnipora*	S
*Pachydictya acuta	S
*Phylloporina trentonensis	S
Phylloporina sp.	S
*Monticulipora wetherbyi	S
Mesotrypa selkirkensis	S
Diplotrypa westoni	D
**Bythotrypa laxata*	S
*Lingula iowensis	D
*Lingula elongata	C
*Lingula obtusa	C
*Dinobolus parvus	S, St
Dinobolus sp.	St
Clitambonites diversa	D
*Anastrophia hemiplicata	D
*Strophomena incurvata	C, S, St
Strophomena fluctuosa	St
Strophomena rugosa	S
*Strophomena trilobata	W, D, S
*Strophomena billingsi	S
*Rafinesquina deltoidea	C

Rafinesquna ceres	St
Rafinesquina alternata	C, S
†Rafinesquina leda	D
Rafinesquina lata	D, C, S
†Leptaena unicostata	C, S
Leptaena nitens	St
Plectambonites sericea	D, C, S
*Orthis tricenaria	D, C
*Orthis pectinella	D
†Dinorthis subquadrata	D, S
†Dinorthis proavita	S, St
Dalmanella testudinaria	W, S, St
Platystrophia biforata	D, S
†Platystrophia crassa	D
†Rhynchotrema capax	D, S, St
*Rhynchotrema inaequivalvis	D, C, St?
Rhynchonella anticostiensis	St
†Rhynchonella anticostiensis var.	S
Zygospira recurvirostra	C
*Cyclospira bisulcata	D
Byssonychia obesa	St
*Byssonychia intermedia	S
Plethocardia sp. nov.	St
Palaeopteria parvula	C
**Modiolopsis parviuscula*	D
Modiolopsis angustifrons	S
Orthodesma affine	S
*Vanuxemia hayniana	D
*Ctenodonta astartaeformis	C
*Ctenodonta subnasuta	C
*Cyrtodonta canadensis	W
Clinopistha antiqua	C
Rhytimya recta	C
Conocardium antiquum	S
Edmondia vetusta	C
*Tetranota bidorsata	C, S
*Salpingostoma buelli	D, S
Conradella sp.	S
Pleurotomaria bicincta	St
Pleucoromaria muralis	D, S
Pleurotomaria acuta	St
Pleurotomaria stokesiana	S
Pleurotomaria margaritoides	C
Liospira americana	D, C
*Liospira persimilis	C
*Liospira angustata	C
Hormotoma gracilis	D, St
Hormotoma winnipegensis	D

*Murchisonia bellicincta	D
Solenospira pagoda occidentalis	W
Bellerophon bilobatus	St
*Cyrtolites compressus	S, St
Cyclora minuta	St
**Maclurina manitobensis*	D, C, S
*Trochonema umbilicatum	D, S, St
**Trochonema eccentricum*	C
*Trochonema niota	D
*Eunema strigillatum	S
Subulites sp.	S
*Fusispira inflata	D, S
*Fusispira elongata	S
Loxonema winnipegense	D
†Conularia asperata	C
Conularia sp.	W
Cephalopods are listed on page 147	
Aparchites whiteavesi	S
Aparchites parvulus	D
Aparchites tyrrelli	W
Aparchites minutissimus	St
Leperditia subcylindrica	St
Primitiella unicornis	St
Primitia lativia	St
Beyrichia parallela	St
Eurychilina manitobensis	St
Tetradella quadrilirata simplex	St
Tetradella lunatifera	St
Calymene senaria	S
Calymene callicephala	St
†Asaphus (Isotelus) susae	D, C, S
Asaphus (Isotelus) gigas	C
Asaphus (Isotelus) maximus	D, C, S
*Illaenus americanus	D, C, S
*Bumastus trentonensis	D, S
*Bronteus lunatus	C
*Pterygometopus callicephalus	S, St
*Cheirurus pleurexanthemus	C, S
Cheirurus icarus	St
Staurocephalus sp.	S
*Lichas cucullus	S
*Encrinurus raricostatus	St
*Conolichas cornutus	S
Harpes sp.	D

In the preceding list a star or asterisk is used to indicate those species listed in Bassler's Index only from horizons beneath the

Cincinnatian, and therefore usually from the Trenton, or Black River, or both. The dagger or obelisk is used to indicate those species from the Red River formation which in Bassler's Index are listed only from strata above the Trenton, and therefore usually either from the Richmond, or Cincinnatian, or both.

This list includes 167 species or varieties, exclusive of the cephalopods. Of this total, 58 species occur in the Stony Mountain formation, 114 occur in the Red River limestones, and 12 in the Winnipeg sandstone. There is a certain amount of overlapping, 13 species being common to the Stony Mountain and Red River formations, and 4 species being common to the Red River limestones and the Winnipeg sandstone. Although the Winnipeg sandstone is lithologically different from the Red River limestones, the fauna from the upper few feet of this sandstone is regarded as merely of slightly earlier age than the Dog River limestone, at the base of the Red River formation, and, faunally, as introductory to the latter. This would give a total of 122 species in the two formations together, the Red River formation and the Winnipeg sandstone. Of this total, 51 species or 42 per cent of the whole are cited in Bassler's Index only from Trenton and Black River strata. On the contrary, only 13 species, or about 10 per cent of the whole are cited in this Index only from Richmond or Cincinnatian strata. Estimating, therefore, on the percentage of relationships shown by the different elements of the Red River fauna, this relationship is chiefly with the Trenton and Black River, and Whiteaves's reference of the strata here included in the Red River formation to the Trenton is readily comprehensible.

In 1897, Whiteaves referred the limestones now included in the Red River formation to the Galena-Trenton. In so doing, he called attention to the fact that their relationship was closer to that phase of the Trenton which dominates the northern part of the Mississippi valley, rather than with that found in New York, southern Ontario, and other eastern areas.

The affinity appears to be greatest with the upper member of the Galena group which is characterized by the abundance of *Maclurina* and *Maclurites*, and also of *Lophospira augustina*.

This member is known as the *Maclurea bed* or the Stewartville formation. In Minnesota it contains the following fauna, those species occurring also in the Red River formation of southern Manitoba being indicated by a star or asterisk.

*Receptaculites oweni	Hormotoma major
*Ischadites iowensis	Hormotoma trentonensis
*Byssonychia intermedia	Lophospira augustina
Cuneamya oblonga	Lophospira augustina minnesotensis
Orthodesma subnasutum	Lophospira perforata
Vanuxemia wortheni	Maclurina cuneata
Coelocaulus oehlerti	*Maclurina manitobensis
*Fusispira inflata	Maclurina subrotunda
Fusispira inflata ventricosa	Maclurites crassus
Fusispira intermedia	*Trochonema umbilicatum
Fusispira subbrevis	"Tripteroceras lambi"

The amount of agreement between the fauna of the Stewartville formation and that of the Red River formation is small if comparison is confined to that part of the fauna of the Red River formation which occurs in southern Manitoba. In that case the species common to both faunas are *Receptaculites oweni, Ishadites iowensis, Byssonychia intermedia, Fusispira inflata, Maclurina manitobensis,* and *Trochonema umbilicatum.* It is possible that the two Stewartville specimens identified by John M. Clarke with *Tripteroceras lambi* Whiteaves belong to that species, or at least belong to the same genus, the Red River form described by Whiteaves having been used as the genotype of the new genus *Lambeoceras.* The siphuncle of the Stewartville specimens is described as "distinctly ventral and moniliform." However, in the specimen actually figured by Clarke no trace of the siphuncle remains. The term *moniliform* is not sufficient to identify the Stewartville form as a true *Lambeoceras.*

If the range of comparison be enlarged so as to include also those extensions of the Red River fauna which occur in other Arctic and Subarctic areas, remote from southern Manitoba, the amount of agreement between the Stewartville and the Red River faunas is increased. From northwestern Greenland, for instance, Troedsson has identified *Receptaculites arcticus, Ishadites* sp., *Fusispira inflata, Fusispira* cf. *subbrevis, Lophospira augustina*

minnesotensis, Lophospira perforata, Maclurina manitobensis, Maclurites crassus, and *Trochonema umbilicatum.* From the head of Frobisher Bay, in southeastern Baffin Land, Schuchert identified *Receptaculites oweni, Ischadites iowensis, Fusispira inflata, Maclurina cuneata, Maclurina manitobensis, Maclurites crassus,* and *Trochonema umbilicatum.* These different lists include 11 of the 22 species known at present from the Stewartville formation of the northern Mississippi valley.

The fossils of the Stewartville formation occur chiefly in the lower half of its vertical section. So many of these Stewartville species occur also in the immediately underlying *Fusispira* member of the Galena phase of the Trenton that it is possible that the Stewartville relationship of the Red River fauna has been stressed too much, and that the comparison of the latter should be made with the Galena as a whole, and not solely with the Stewartville member of the latter. Relationship of the Red River formation with the *Fusispira* member of the Galena is suggested, for instance, by the species described by Clarke under *Oncoceras minnesotense.* The structure of the siphuncle of this species is identical with that of the species described by Whiteaves under the name *Cyrtoceras manitobense.* Moreover, the course of the sutures of the septa of the two species agrees. However, it is not known that the mature stages of the conch of *Oncoceras minnesotense* have any resemblance to those of *Cyrtoceras manitobense,* though the possibility is admitted.

From the preceding lines it is evident that a considerable part of the fauna of the Red River formation shows affinities with the Trenton, especially with the Galena phase of the Trenton. However, the direct correlation of the Red River formation with the Galena phase of the Trenton becomes less certain when the cephalopod fauna of the Red River formation is studied, especially if this study be extended so as to include not only the Red River formation as exposed in southern Manitoba, but also its equivalent elsewhere in Arctic and Subarctic areas.

Among the species of cephalopods listed on page 147, 46 species occur in the Red River formation. Of these, 30 occur in the Dog Head limestone, 4 in the Cat Head limestone, and 22 in the

Selkirk limestone. Among the 4 that occur in the Cat Head limestone, none are confined to that horizon. *Cyclendoceras whiteavesi* and *Cyrtogomphoceras whiteavesi* occur in all three members of the Red River formation. *Narthecoceras simpsoni* and *Diestoceras apertum* occur also in the underlying Dog Head member. *Charactoceras plicatum, Ormoceras lambei,* and *Diestoceras nobile* occur both in the Dog Head and in the Selkirk members of this formation, and none of these four species has been found so far in the intermediate Cat Head member. From this it will be seen that the cephalopod fauna of the Dog Head member is readily distinguishable apparently from that of the Selkirk member, at least in the present state of our knowledge of these faunas.

However, when it is attempted to correlate the extensions of the Red River formation in areas remote from southern Manitoba with the members as established in the typical Red River area, difficulties arise. For instance, in the area southwest of Hudson Bay the Nelson limestone may correspond to the Dog Head member of the Red River formation, and the Shammattawa limestone may correspond to the Selkirk member, or may be even of somewhat later age than the Selkirk. The exposures at Putnam Highland, east of the northern margin of Foxe Land, in the southern part of Baffin Island, appear to correspond to the Dog Head member of the Red River formation. The exposures on Igloolik Island, northwest of Foxe Land, possibly belong to the same member. Those at Cape Calhoun, along the northern margin of Kane basin, in northwestern Greenland, may belong partly to the Dog Head and partly to the Selkirk member of the Red River formation. At present too little is known of the vertical distribution of fossils from this Red River formation in any area outside of southern Manitoba. This gives special importance to the southern Manitoba area, since it promises to serve as a key in the solution of uncertainties in stratigraphy presented by those areas in which the opportunities for determining the stratigraphic sequence of the different faunas are less favorable. At present, the best that can be said of the Red

River fauna as a whole is that it can be distinguished readily from the overlying Stony Mountain fauna.

Among the most characteristic and widely distributed genera of cephalopods of the Red River formation (page 147) are *Cyrtogomphoceras* and *Westonoceras*. Both of these genera occur in southern Manitoba, and also west of Hudson Bay, east of Foxe Land, and in northwestern Greenland. It is possible that *Westonoceras* occurs also in the middle or Fusispira member of the Galena phase of the Trenton in Minnesota. At least, the species described by John M. Clarke under the name *Oncoceras minnesotense* is very similar in the structure of its siphuncle and in the course of the sutures of its septa, though nothing is known of the general form of its conch at mature stages of growth. *Narthecoceras* is known both from southern Manitoba and from northwestern Greenland. The correctness of the identification of the specimen from southern Manitoba here figured under the name *Calhounoceras* remains in doubt. That type of structure represented by *Charactoceras plicatum* in southern Manitoba probably is congeneric with that of *Charactoceras schucherti* from the head of Frobisher Bay, in southern Baffin Island. However, it remains to determine whether these two species are congeneric with typical *Charactoceras*, as represented by *Charactoceras baeri* (Meek and Worthen). The representatives of the Red River formation, at least, present distinct transverse ribs laterally, in addition to the more continuous transverse striae, and the segments of the siphuncle enlarge more moderately within the camerae. *Kochoceras* has been identified so far only from strata belonging to the Red River formation, but there are somewhat similar species from the Trenton and Black River formations of Tennessee and other central states whose exact generic relationships have not yet been determined, which might belong to that genus. So far, *Kochoceras* has been identified from northwestern Greenland, Igloolik island, the area southwest of Hudson Bay, the southern part of Manitoba, and Great Slave Lake. The species described by Alice E. Wilson as *Actinoceras complanum*, from the Beaverfoot member of the Richmond formation at Palliser Pass, south of Banff in British Columbia, possibly is a

species of *Kochoceras*. The species of *Leurorthoceras* described from the Putnam Highlands east of the northern margin of Foxe Land in southeastern Baffin Island evidently is closely related to the species described by Troedsson from the northwestern part of Greenland under the name *Leurorthoceras ruedemanni*, but it is not yet certain that these two species are strictly congeneric with *Leurorthoceras hanseni*, the type of the genus *Leurorthoceras* from the King William Land or Boothia Felix area, or with *Leurorthoceras chidleyense* from the northern end of Labrador, both of which species were interpreted as of Black River age.

However, this leaves a number of forms whose affinities are distinctly with Richmond or overlying formations. For instance, the Maquoketa of Iowa contains *Billingsites* and *Ephippiorthoceras;* also a form which appears identical with *Charactoceras baeri*. The last named species was described originally from the Richmond of Indiana; it occurs also in Ohio, and was described by Troedsson from the equivalent of the Red River formation in northwestern Greenland. It is closely related to *Charactoceras hercules* (Billings) from the Richmond of Anticosti. Moreover, the Maquoketa of Iowa contains representatives of that division of the genus *Cyclendoceras* in which the annulations are relatively numerous, as in the Red River species *Cyclendoceras whiteavesi* here described.

The Richmond of Indiana and Ohio contains *Billingsites, Lambeoceras,* and the species *Charactoceras baeri,* already mentioned. These three species, associated with the genotype of *Diestoceras,* occur in the lower part of the Whitewater member of the Richmond, and therefore considerably above the base of the Richmond. However, *Diestoceras* appears to occur also in the Trenton and Black River, and the specimens from the upper or Stewartville member of the Galena phase of the Trenton in Minnesota referred by John M. Clarke to *Tripteroceras lambi* Whiteaves may belong to the genus *Lambeoceras,* though, in the absence of any knowledge of the structure of the siphuncle of the mature form of the Minnesota specimens, this can not be definitely asserted as yet.

On the island of Anticosti the Richmond contains *Apsidoceras, Billingsites, Charactoceras hercules, Diestoceras,* and *Ephippiorthoceras.* The genera *Apsidoceras, Billingsites, Diestoceras,* and *Ephippiorthoceras* are represented also in the equivalents of the Red River formation in the area southwest of Hudson Bay. *Charactoceras hercules* is a close relative of the genotype *Charactoceras baeri. Ephippiorthoceras* is not known at present from any formation beneath the Richmond. It occurs at almost all known exposures of the Red River formation, including that at the head of Frobisher Bay. It is well represented in the Richmond of Anticosti, and is known also in the Maquoketa of Iowa. The species described by Foerste from the Richmond of Anticosti under the name *Spyroceras microlineatum* evidently is very closely related to the species described earlier by Troedsson from the equivalent of the Red River formation in northwestern Greenland under the name *Spyroceras aquilonare* (Troedsson). Moreover, the species described by Foerste from the Richmond of Anticosti under the name *Hyperoceras twenhofeli* certainly is generically identical with the earlier described genus and species *Danoceras ravni* Troedsson from the Red River formation of northwestern Greenland, and it may be even specifically identical, though this is not certain at present. At any rate, the name *Hyperoceras* becomes a synonym of *Danoceras.*

The presence of *Huronia* in strata of earlier age than the Silurian was announced first by Parks, who described *Huronia septata* from the Shammattawa limestone southwest of Hudson Bay. Since then, additional species have been described from the equivalent of the Red River formation in northwestern Greenland, and from typical representatives of this formation in southern Manitoba. It is of interest that the species occurring in southern Manitoba, *Huronia occidentale* Foerste, appears to be identical with the type of that species which was found in the vicinity of Mocassin Mountain, in the Big Horn Range of Wyoming, in strata regarded as of Richmond age.

Elsewhere, *Huronia* is known at present only from the Middle Silurian. On Anticosti Island, it occurs in the Jupiter and Chicotte formations. The Jupiter has been shown by Twen-

hofel to be of Clinton age. Recently, Schuchert and Dart have shown the presence of *Huronia* also in the Port Daniel-Gascons area, southwest of Anticosti, in strata approximately of the same age as the Jupiter formation. In northern Michigan, *Huronia* is common in the Manistique formation, and it occurs in the equivalent of the Manistique in the Lake Timiskaming area. In Iowa it occurs in the Hopkinton dolomite, which appears to be approximately of the same horizon as the Manistique. There is a possibility of the Manistique and Hopkinton being of Clinton age. However, M. Y. Williams cites *Huronia vertebralis* from the upper part of the Lockport on South Bay on Manitoulin island, and, until this Manitoulin specimen has been found and its horizon verified, it is not safe to assert, from the presence of *Huronia* alone, that the Manistique and Hopkinton are of Clinton age.

On Anticosti, *Apsidoceras*, *Billingsites*, and *Ephippiorthoceras* continue their vertical range from the typical Richmond upward into the Ellis Bay formation, which, in addition to species having a distinctly Ordovician facies, includes forms which in Ohio and Indiana are unknown until Brassfield time.

In a similar manner, *Apsidoceras* and *Billingsites* are known in the Baltic areas of Europe from strata containing early representatives of Silurian genera, associated with fossils suggesting Ordovician affinities. In Norway these strata are known as the Gasteropod limestone; in Sweden, as the Leptaena limestone; and in Esthonia, as the Lyckholm. Formerly, these strata were regarded as forming the uppermost representatives of the Ordovician in Baltic areas, but recently the strata here under discussion have been placed definitely at the base of the Silurian.

In the Ringerike area, southwest of Oslo in Norway, *Apsidoceras* (pl. XXVII, fig. 2) and three species of *Billingsites* occur in the Gasteropod limestone. In the Dalarne area northwest of Stockholm in Sweden, *Apsidoceras hedstroemi* Foerste (pl. XXVII, fig. 1) and *Billingsites troedssoni* Foerste (pl. XX, fig. 3) occur in the Kallholn or Upper Leptaena limestone. *Billingsites deforme* Eichwald (pl. XX, fig. 4) was described from erratic material, probably of Lyckholm age, in the vicinity of Hohenholm on the

island of Dagö, west of the northern border of the mainland of Esthonia. All three of these occurrences, in Norway, Sweden, and Esthonia, occur at approximately the same horizon, namely at the base of the Silurian, as stated above.

Until recently, the Leptaena limestone of Sweden offered a puzzle in stratigraphy, but Elsa Warburg demonstrated that this limestone, as ordinarily identified, included two very distinct horizons, of which the upper, later called *Kallholn* by Troedsson and Roswall, is Silurian, while the lower part has its nearest affinities with the *Chasmops macrourus* limestone, and is distinctly Ordovician. To this Ordovician part they gave the name *Kullsberg*.

In Norway, the Gasteropod horizon is characterized by the appearance of an abundance of corals representing such genera as *Columnaria, Palæofavosites, Plasmoporella, Proheliolites, Propora, Protaraea,* and *Ptychophyllum*. Another genus from this horizon, *Syringophyllum*, apparently is a later development from the *Calapoecia* stock of corals. In Sweden, the corresponding Leptaena limestone contains *Calapoecia amphigenia* Lindström, *Favosites forbesi* Edwards and Haime, *Halysites catenularius* Linnaeus, *Halysites escharoides* Lamarck, *Halysites parvitubus* Lindström, *Heliolites dubius* Fr. Schmidt, *Heliolites intricatus-lamellosus* Lindström, *Plasmoporella affinis* Billings, *Plasmoporella conferta* Edwards and Haime, *Stylaraea roemeri* von Seebach, and *Syringophyllum organum* Lindström. Moreover, in all three countries the horizons here indicated include species which in America are known first in the lower part of the Silurian; in Norway, for instance, such forms as *Meristella crassa* and *Rhynchotreta cuneata*.

In other words, the affinities of *Apsidoceras* and *Billingsites* are with the Richmond and overlying Silurian rather than with the Trenton.

Some of the corals occurring in the Red River formation also suggest affinities with the Richmond, rather than with the Trenton. *Columnaria stokesi*, for instance, is not known anywhere in the Trenton, but it occurs on the peninsula east of Escanaba, in northern Michigan, only in the highest part of the Richmond

there exposed. This is true also of *Halysites gracilis*. *Paleofavosites prolificus* is another coral known only from the Richmond. In the Red River formation, *Columnaria stokesi* is known only from the upper or Selkirk member. *Palaeofavosites prolificus* also is known only from the Selkirk member, as far as its range in the Red River formation is concerned, but it occurs also in the overlying Stony Mountain formation. *Halysites gracilis*, however, occurs in all three members of the Red River formation. *Calapoecia huronensis* (Billings) occurs in the Dog Head and Selkirk members of the Red River formation, as well as in the Stony Mountain formation. Its earliest occurrence (as *Calapoecia cribriformis*) in the Ohio River valley, is in the lower part of the Liberty member of the Richmond.

It is true that *Calapoecia canadensis* Billings was described from the Black River formation of the Ottawa district, in Canada, and that *Halysites catenularia quebecensis* Lambe was described from the Black River formation on the western shore of Lake St. John in the northern part of the province of Quebec. It should be noted, however, that when Lambe studied the specimens of *Halysites* at his command, he referred the species from the Red River formation at Jack Head, the limestone rapids of Nelson River, north of the Grand Rapids of the Saskatchewan, and at Churchill harbour on Hudson Bay, to *Halysites catenularia gracilis* (Hall), together with the *Halysites* found in the English Head member of the Richmond on Anticosti Island, and not to the Black River variety which he named *quebecensis*. With *Calapoecia* he was not equally successful, possibly because he regarded the Red River specimens as of intermediate age, between the Black River and Richmond, instead of being of about the same age as the Richmond. At any rate, *Calapoecia* is very rare in the Black River formation, the colonies are very small, the corallites are relatively small, and such specimens as I collected myself and saw in the collections in the Geological Survey of Canada appeared to me distinguishable from those in the Richmond, though I might change my mind on making a detailed study of the series. In the mean time, it is of interest to note that the nearest relative of *Columnaria stokesi*, mentioned above,

is *Columnaria vaurealensis* Twenhofel from the Richmond of Anticosti Island.

As for the brachiopods, such species as *Leptaena unicostata, Dinorthis subquadrata, Rhynchotrema capax,* and *Rhynchotrema anticostiense* usually are considered as index fossils of the Richmond. Such genera as *Dinobolus, Clitambonites,* and *Parastrophia* occur not only in the Black River or Trenton, but also in Richmond or later horizons.

Among the gasteropoda, nothing like *Maclurina* or *Maclurites* is known in Richmond faunas outside of the distribution of the Red River formation. *Maclurina manitobensis acuta* Parks and *Maclurites subovatus* Parks occur in the Shamattawa member of the Red River formation in the area southwest of Hudson Bay, an horizon which appears as closely allied to the Richmond as anything in the Red River formation.

Among the trilobites, *Onchometopus susae* is a Richmond form. *Ceraurinus icarus,* identified by Troedsson from northwestern Greenland, is another Richmond species. Such forms as *Goldius* and *Amphilichas* occur not only in earlier strata but also in the Richmond and later formations.

From the preceding lines it is evident that, while the prevailing Trenton and Black River facies of the fauna of the Red River formation is admitted, species with Richmond affinities also occur. The question is what bearing these facts should have on the correlation of the Red River formation with other formations usually accepted as standards in preparing a geological time scale.

If correlated on the basis of the percentage of the species of a given recognized age present—a time-honored custom—this Red River formation could readily be regarded as Trenton.

However, the relatively abrupt introduction of an important number of genera or species usually regarded as indicative of Richmond age suggests that these Richmond forms were not evolved in the areas where the Red River formation prevails, but in some other area, from which the Richmond forms found in the Red River formation are merely migrants. In this other area, from which the migrants came, evolution may have started

earlier, or may have been more rapid. The migrants may represent only a small part of the Richmond fauna already in existence in this other area. Evidently Richmond time may have been already well advanced in this other area, though just beginning to become evident within the area in which the fauna of the Red River formation prevailed. Under these circumstances, shall the Red River fauna be regarded as still Trenton, or shall the inauguration of Richmond times be recognized?

Questions of this type have been up for decision for many years, and they have been decided differently. For instance, shall the Richmond formation be regarded as Ordovician or Silurian? Is the Ellis Bay formation Ordovician or Silurian? Shall the Catheys be regarded as Trenton or as a part of the Cincinnatian?

The present problem is whether the Red River formation shall be regarded as of Trenton or of Richmond age. The answer will depend on the point of view of the investigator. Prevalence of a general Trenton facies suggests its Trenton age. The introduction of an important number of characteristic Richmond genera and species suggests its reference to the Richmond. The present writer favors the latter procedure. However, he recognizes the fact that an intensive study of the other faunal groups represented in the Red River formation, aside from the cephalopods, is desirable before coming to a final conclusion. So many years have elapsed since Whiteaves and Dowling referred the great majority of species from this formation to Trenton forms, that it is desirable that these faunas be restudied, to see if the former identifications will stand the test of more exact methods of paleontological research, with the help of more and better comparative material.

In the preparation of the present paper the writer has been greatly aided as heretofore by Dr. E. M. Kindle, Paleontologist of the Geological Survey of Canada, and by Alice E. Wilson, who, together with Madeleine A. Fritz, collected most of the material secured since the days of Whiteaves and Dowling. Both specimens and direct information were freely placed at the disposal of the writer for which he here expresses his greatest appreciation.

LIST OF CEPHALOPODS HERE DESCRIBED

1. Endoceras sp. (11–14 camerae) ..... D
2. Endoceras manitobense Foerste (7 camerae) ..... D
3. Endoceras sp. (4 camerae) ..... D
4. Endoceras sp. (siphuncle only) ..... D
5. Cyclendoceras kindlei Foerste (Hudson Bay) .....
6. Cyclendoceras whiteavesi Foerste ..... D, C, S
7. Cameroceras wilsoni Foerste (endocone only) ..... S
8. Billingsites costulatum (Whiteaves) ..... D
9. Orthoceras sp. (East Selkirk) ..... S
10. Cycloceras selkirkense (Whiteaves) ..... S
11. Spyroceras cf. aquilonare (Troedsson) ..... D
12. Spyroceras fritzi Foerste ..... D
13. Ephippiorthoceras cf. formosum (Billings) ..... S
14. Garryoceras semiplanatum (Whiteaves) ..... S
15. Whiteavesites winnipegensis (Whiteaves) ..... D
16. Dowlingoceras gracile (Whiteaves) ..... D
17. Charactoceras(?) plicatum (Whiteaves) ..... D, S
18. Charactoceras(?) schucherti Foerste (Frobisher Bay) .....
19. Discoceras canadense Whiteaves ..... D
20. Wilsonoceras mccharlesi (Whiteaves) ..... D, S, St
21. Narthecoceras crassisiphonatum (Whiteaves) ..... S
22. Narthecoceras simpsoni (Billings) ..... D, C
23. Calhounoceras cf. candelabrum Troedsson ..... D
24. Actinoceras bigsbyi Bronn (Thessalon Island) .....
24A. Actinoceras cf. bigsbyi Bronn ..... D
25. Kochoceras tyrrelli Foerste ..... D
25A. Kochoceras cf. tyrrelli Foerste (Great Slave Lake) .....
26 Selkirkoceras cuneatum Foerste ..... S
27. Selkirkoceras tyndallense Foerste ..... S
28. Armenoceras richardsoni (Stokes) ..... S
29. Armenoceras sp. (Stony Mountain) ..... St
30. Armenoceras cf. allumettense (Billings) ..... S
31. Armenoceras sp. (Great Slave Lake) .....
32. Ormoceras lambei Foerste ..... D, S
33. Paractinoceras canadense (Whiteaves) ..... D
34. Huronia occidentalis Foerste ..... S
35. Lambeoceras lambii (Whiteaves) ..... S
36. Lambeoceras cf. princeps Troedsson ..... D
37. Winnipegoceras laticurvatum (Whiteaves) ..... D
38. Winnipegoceras dowlingi Foerste ..... D
39. Winnipegoceras sp. (near McBeth point) ..... S
40. Oxygonioceras (?) latum Foerste ..... D
41. Westonoceras manitobense (Whiteaves) ..... D
42. Westonoceras nelsonense Foerste (Hudson Bay) .....
43. Diestoceras nobile (Whiteaves) ..... D?, S
44. Diestoceras(?) whiteavesi Foerste ..... D

45. Diestoceras(?) sp. (Black island) ..... D
46. Diestoceras gibbosum Foerste ..... S
47. Diestoceras apertum (Whiteaves) ..... D, C?
48. Cyrtogomphoceras magnum (Whiteaves) ..... S
49. Cyrtogomphoceras whiteavesi (Miller) ..... D, C?, S?
50. Cyrtogomphoceras cf. turgidum Troedsson ..... D
51. Cyrtogomphoceras(?) intermedium (Whiteaves) ..... D

ADDITIONAL CEPHALOPODS FIGURED OR DESCRIBED

Kindleoceras reversatum Foerste	Plate	XVI, page 167
Murrayoceras murrayi (Billings)	Plate	XVI, page 167
Discoceras sp. (Norway)	Plate	XX, page 176
Billingsites troedssoni Foerste	Plate	XX, pages 142, 157
Billingsites deforme (Eichwald)	Plate	XX, pages 142, 157
Apsidoceras hedstroemi Foerste	Plate	XXVII, page 142
Apsidoceras sp. (Norway)	Plate	XXVII, page 142

NEW GENERA

WHITEAVESITES; genotype, *Orthoceras winnipegense* Whiteaves. page 167
WILSONOCERAS; genotype, *Trochoceras mccharlesi* Whiteaves ... page 180
SELKIRKOCERAS; genotype, *Selkirkoceras cuneatum* Foerste .... page 199
REEDSOCERAS; genotype, *Cyrtoceras macrostomum* Hall ..... page 233

ENDOCERAS Hall

Accepted genotype: *Endoceras proteiforme* Hall, Pal. New York, 1, 208, pl. 48, fig. 4; pl. 49, figs. 1 a–e; also Foerste, Journ. Sci. Lab. Denison Univ., 20, 210, pls. 21, 22, 23, 25.

Holochoanoidal orthocones in which the endocones are long, funnel-like, and without any trace of low annulations. The surface of the conch also is free of annulations. In typical forms, the diameter of the siphuncle compared with that of the conch is relatively large.

1. **Endoceras** sp. (11–14 camerae)

Specimen in a boulder 178 mm. long, and occupying almost its entire length. That part which is exposed varies in width from 60 mm. to 65 mm. in a length of 90 mm. At the smaller end of the specimen the siphuncle is exposed for a width of 23 mm. The number of camerae along a length equal to the exposed width of the specimen varies from 11 along the lower half of the specimen

to 14 along its upper half. The siphuncle evidently is excentric in location, but it can not be determined how great this excentricity is since the orientation of the specimen with reference to the median dorso-ventral plane is unknown. It is evident, however, that the septa slope downward at a much steeper angle on the ventral side of the siphuncle than dorsally. The septal necks appear to present concave vertical outlines.

Locality and horizon—Black Bear island, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 6795, Victoria Memorial Museum. Collected by Alice E. Wilson and Madeleine A. Fritz.

Remarks.—This specimen appears to be a new species, but it is not suitable to serve as a type, since its orientation is unknown, and the diameters of both the conch and the siphuncle are uncertain, only a relatively thin film of the specimen remaining on the surface of the boulder.

2. **Endoceras manitobense** Sp. nov. (7 camerae)

Plate XII, fig. 1

Specimen 130 mm. long, and exposing a width of 130 mm. Its original width, however, is estimated at 150 mm. The siphuncle was about 70 mm. in diameter, and its nearest part is 25 mm. from the ventral wall of the conch. Five camerae occupy a length of 108 mm., indicating the presence of about 7 camerae within a length equal to the diameter of the conch. The concavity of the septa is about 40 mm., ignoring the sigmoid downward curvature of the septa on approaching the siphuncle. This sigmoid curvature extends about 5 mm. beneath the general concave curvature of the septa before the septal funnels become almost cylindrical in form. The lower part of the septal funnels contracts slightly in order to invaginate into the septal funnels beneath, the length of this invagination equalling 7 or 8 mm. The middle part of the septal funnels does not enlarge into more or less conspicuous annulations as in most other species of *Endoceras*.

Locality and horizon.—Biscuit Point, Narrows, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 6800, Victoria Memorial Museum.

A second specimen, numbered 6810, was found at Dog Head, Narrows, Lake Winnipeg, also in the Dog Head member. Its camerae equal in length those of the preceding specimen.

A third specimen, numbered 6014, was found at the southeast point of Berens Island; in the Dog Head member. Its camerae are similar in length to those of the preceding specimens; its present width is 135 mm., but originally its diameter probably was nearer 160 mm.

All three specimens here described were collected by Alice E. Wilson and Madeleine A. Fritz.

Remarks.—In the species described as *Cameroceras hennepini* by Clarke, from the Prosser member of the Trenton in Minnesota, the siphuncle is more central in location, but the number of camerae, where the conch is equally large, probably is about the same as in the Manitoba species. One of the characteristic features of the Minnesota species is the downward flexure of the suture of the septa along the ventral side of the conch. In one of the specimens which is figured as belonging to the same species this downward flexure is angular along the median line. Ordinarily such an angularity would not be expected in a conch whose siphuncle was central in location. The course of the septa of the Manitoba species is not known along its median side, so that the excentric location of its siphuncle is the only distinguishing feature known at present.

3. **Endoceras** sp. (4 camerae)

Specimen 190 mm. long, with a diameter of at least 85 mm. Four camerae occupy a length of 65 mm. along the lower part of the specimen and the same number of camerae occupy a length of only 50 mm. along its upper part. Traces of the siphuncle occur along the middle of one of the weathered sides of the specimen.

Locality and horizon.—Dog Head, Narrows, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. No. 6812, Victoria Memorial Museum.

Another specimen in the same collection is numbered 6795. It is from Black Bear island, and also came from the Dog Head member.

A third specimen in this collection is numbered 5600. It is labelled as coming from Deer island, and was found in the Dog Head member. All three specimens were collected by Alice E. Wilson and Madeleine A. Fritz. All three appear to belong to the same species, but their state of preservation does not admit of more definite identification.

A fourth specimen, numbered 6802, is similar in having four camerae in a length of 55 mm. The specimen is 195 mm. long, and its diameter was at least 105 mm. It probably belongs to the same species as the preceding three specimens, though this is less certain. It was collected by Alice E. Wilson in the interval between the sandstone and limestone on Bull Head, Narrows, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation.

Compared with the casts of the interior of *Cyclendoceras whiteavesi* Foerste, the camerae of the specimens here described are relatively taller.

4. **Endoceras** sp. (Siphuncle only)

A fragment of a siphuncle 115 mm. long, enlarging from a lateral diameter of 54 mm. at its base to 59 mm. at its top. Crossed by very low annulations which slope at an angle of 15 degrees with the horizontal from the ventral toward the dorsal side of the siphuncle. These annulations occur immediately above the points where the septal funnels curve downward from the septa at which they originate. At these annulations the lower parts of the next succeeding funnels first expand and then contract so as to fit tightly into the top of the funnels beneath. Between these annulations the vertical outlines of the funnels are slightly concave. Judging from these annulations, about 4 camerae occupied a length equal to the lateral diameter of the siphuncle.

Locality and horizon.—Big Grindstone Point, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. Specimen No. 6002, Victoria Memorial Museum. Collected by J. B. Tyrrell, No. 14, May 28, 1889.

CYCLENDOCERAS Grabau and Shimer

Genotype: *Endoceras annulatum* Hall, Pal. New York, 1, 207, pl. 44, figs. 1 a, b (1847); *Cyclendoceras annulatum* Grabau and Shimer, North Amer. Index Fossils, 2, 43, fig. 1241 (1910); Foerste, Jour. Sci. Lab. Denison Univ., 19, 299, pl. 31, fig. 3; vol. 23, pl. 3, fig. 1.

Cyclendoceras differs from *Endoceras* only in the presence of annulations on the surface of the shell. In the type of the genus the diameter of the conch is about 60 mm., and the number of annulations in a length equal to the diameter of the conch is about 6 or 7. However, some species occur in which the diameter of the conch equals or exceeds 100 mm., and in which the number of annulations in a length equal to the diameter of the conch is about twice as great as in the type. One of these is the species described here from the Red River formation of southern Manitoba under the name *Cyclendoceras whiteavesi*. Another occurs in the Richmond of the Big Horn range of Wyoming and in the Teton range of Idaho. A third is found in the Maquoketa of southeastern Iowa. All of these belong in faunas apparently of northern origin.

5. **Cyclendoceras kindlei** Sp. nov.

Plate XII, fig. 2; Plate XXII, fig. 2

Endoceras annulatum var. Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 77, pl. 5, figs. 1, 1a (1892).

Specimen 145 mm. long, evidently enlarging very slowly within this length, but the exact rate of its enlargement can not be determined. At the top of the specimen its maximum diameter is about 45 mm. in the present flattened condition of the specimen. This flattening is chiefly lateral, but somewhat diagonal. The number of camerae in a length of 45 mm. varies from 6 at the lower end of the specimen to 7 at its upper end. The sutures of the septa appear to have been almost directly transverse. The annulations on the surface of the shell, however, were strongly oblique, sloping downward from the dorsal toward the ventral side of the conch at an angle of about 15 degrees with

the horizontal. These annulations are conspicuously defined even on the cast of the interior of the conch, where their rounded crests rise fully 1 mm. above the broad intermediate grooves. About 5.5 annulations occur in a length of 45 mm. The concavity of the septum at the top of the specimen equals 8 mm. The maximum diameter of the siphuncle here is 18 mm.

Locality and horizon.—Between the second and third rapids of the Nelson river, west of Hudson Bay; in the Nelson limestone. Collected by Dr. Robert Bell in 1879. Specimen No. 1840.

Remarks.—This species is readily distinguishable from *Cyclendoceras boreale* Foerste,[1] from the Black River limestone found erratic at Port Burwell, west of Cape Chidley, Labrador, by the smaller size of its siphuncle, its shorter camerae, and much more conspicuous annulations.

6. **Cyclendoceras whiteavesi** Sp. nov.

Plate XI, fig. 1

Endoceras subannulatum Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 78, pl. 5, figs. 2, 2a (1892). *Cyclendoceras whiteavesi* Foerste, Jour. Sci. Lab., Denison Univ., 24, 29, (1929).

Swampy or Berens Island specimen.—Specimen 310 mm. long, its lateral diameter enlarging from 95 mm. to 111 mm. in a length of 220 mm. These measurements of the lateral diameter are only approximate, the specimen being greatly flattened dorso-ventrally by pressure, and the lateral margins of the specimen not being clearly defined. The specimen exposes only the dorsal side of the conch, the annulations on the surface of the shell rising distinctly here. Usually there are 6 annulations in a length of 25 mm. The shell has a thickness of about 2.5 mm. at the crest of the annulations, and of 1.5 mm. at the intervening grooves. The crest of these annulations is rounded, but, owing to their height and narrowness, the annulations are conspicuous. The number of camerae in a length equal to the lateral diameter of the specimen varies from 10 along its lower third to 12 along

[1] Foerste, Aug. F. Jour. Sci. Lab., Denison Univ. 23, 15, pl. 1, figs. 1A, B; pl. 22, figs. 2A, B (1928).

its upper third. From the south-east point of Berens Island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. Specimen No. 5599, collected by Alice E. Wilson and Madeleine A. Fritz. Plate XI, fig. 1.

Big Sturgeon Island specimen.—Specimen 150 mm. long and apparently 135 mm. wide, exposing on one face the dorsal side with its upward curving annulations and on the other face the ventral side exposing part of the siphuncle. At the lower end of the specimen this siphuncle appears to be 55 mm. in diameter. According to the annulations crossing the siphuncle diagonally, this siphuncle was located close to the ventral wall of the conch and the number of camerae occurring in a length equal to the lateral diameter of the conch equals about 14. These annulations are relatively conspicuous; their crests are broadly rounded, but the intermediate grooves, though shallow, are still broader. These intermediate grooves locate those parts of the septal necks along which the vertical outline of the necks is concave. The annulations are located at the lower end of the septal necks, where the moderately expanded part of the necks contracts so as to enter the top of the septal funnels beneath. The specimen is labelled as coming possibly from Big Sturgeon Island, and as having been collected by D. B. Dowling. It is from the lower or Dog Head member of the Red River formation. Specimen No. 5601.

East Selkirk specimen.—This specimen, figured by Whiteaves, originally was numbered 1474, but its present location is unknown. However, the figure presented by Whiteaves provides the following data. That part of the specimen which he figured enlarged from a dorso-ventral diameter of 84 mm. at its base to 99 mm. at a point 190 mm. farther up. The concavity of the septum at its base was about 20 mm. The siphuncle was 37 mm. in diameter where the diameter of the conch was 84 mm. Its ventral side was about 4 mm. distant from the ventral wall of the conch. The oblique markings crossing the siphuncle suggest that the camerae were 9 mm. in height along the lower part of the specimen. The shell was relatively thick, at least along the annulations. These annulations sloped downward from the dorsal

toward the ventral side of the conch at an angle of 15 degrees with the horizontal. From 5 to 6 annulations occurred within a length of 25 mm. almost uniformly along the specimen. The specimen was found at East Selkirk. This suggests its derivation from the Upper or Selkirk member of the Red River formation.

Whiteaves, in his description of the preceding specimen, cites its occurrence also from Grindstone Point, Cat Head, Swampy or Berens Island, Snake Island, Jack Head (near Pike Head), Black Island (near Berens Island), and Big Sturgeon Island. All of these additional localities belong to the lower and middle members of the Red River formation. Apparently this species occurs in all three members of the Red River formation, but most of the specimens known so far are from the lower or Dog Head member.

CAMEROCERAS Conrad

Genotype: *Cameroceras trentonensis* Conrad, Jour. Acad. Sci. Philadelphia, 8, 267, pl. 16, fig. 3 (1842); Hall, Pal. New York, 1, 221, pl. 56, figs. 4 a–c; Foerste, Jour. Sci. Lab. Denison Univ., 20, 213, pl. 24, figs. 1–5 (1924).

Cameroceras differs from *Endoceras* chiefly in the shortness and greater obliquity of its endocones. The latter tend to be distinctly annulated in a direction parallel to the adjacent oblique part of the septa.

7. **Cameroceras wilsoni** Sp. nov.

Plate XVII, figs. 4 A, B, C, D

Specimen regarded as an endocone, 61 mm. long, enlarging laterally from a diameter of 3 mm. at its base to 29 mm. at a point 40 mm. farther up. Above this point it appears to maintain the same width. The ventral vertical outline is approximately straight, and for a width of about 10 mm. the ventral side of the specimen is smooth and somewhat flattened, as though in contact with the relatively flattened ventral wall of the siphuncle. The lower part of the dorsal outline of this endocone diverges from its ventral outline at an angle of 40 degrees for a length of

27 mm., and then curves increasingly upward until a height of 35 mm. above the base of the specimen is attained. Here the dorso-ventral diameter reaches a maximum of 25.5 mm., above which it appears to shorten, though this appearance may be due to depression of the upper third of the length of the specimen. The line of demarcation between the endocone and the siphuncle can not be determined with confidence, but the more rapidly enlarging part, for a length of 37 mm., is here regarded as unquestionably belonging to the endocone, while the overlying part probably belongs to the siphuncle. However, if that is the case, the evidence is not satisfactory. The annulations along the upper part of the specimen number 6 in a length of 33 mm., when the specimen is viewed as in fig. 4C on plate XVII. The seventh annulation is 7 mm. farther down, but is distinctly weaker. The annulations are distinct dorsally and laterally, but disappear along the middle part of the ventral side, as already stated. These annulations slope distinctly downward from the ventral toward the dorsal side of the conch, the angle with the horizontal being about 5 degrees at mid-length of the specimen. It will be noted that the annulations are distinct along the upper half of that part of the specimen assigned to the endocone. A very faint trace of an eighth annulation is located about 11 mm. above the pointed base of the specimen. This pointed base has an aperture about 2 mm. in diameter, probably connected with a central, more or less tubular passage, similar to that found in the interior of the basal portion of endocones of other holochoanoidal genera.

Locality and horizon.—Tyndall, Manitoba; from the upper or Selkirk member of the Red River formation.

Specimen No. 6015, Victoria Memorial Museum.

BILLINGSITES Hyatt

Genotype: *Ascoceras canadense* Billings, Geol. Surv. Canada, Rept. Progress for 1853–56, 310 (1857); *Billingsites canadensis* Hyatt, Boston Soc. Nat. Hist. 22, 278 (1884); Foerste, Geol. Surv. Canada, Memoir 154, 260, pl. 40, fig. 3 (1928); Trans. Royal Soc. Canada, 22, sec. 4, 225, pl. 1, figs. 1, 2 (1928).

Billingsites differs from *Ascoceras* chiefly in the fact that its gerontic ovoid cluster of living chambers is depressed dorso-ventrally instead of being compressed laterally. In addition, the upper part of this ovoid cluster tends to be less elongated beyond that part of the conch which equals in elevation the crest of the uppermost dorsal saddle of the sutures.

Billingsites is widely distributed on the American continent, occurring on Anticosti, in the area southwest of Hudson Bay, in the southern part of Manitoba, on the peninsula east of Escanaba in northern Michigan, in southeastern Iowa, and in southwestern Ohio. In European areas it is represented by three species in the Ringerike area southwest of Oslo, in Norway; by *Billingsites troedssoni* Foerste (pl. XX, fig. 3) in the Dalarne area northwest of Stockholm, in Sweden, and by *Billingsites deforme* (Eichwald) (Pl. XX, fig. 4) in Esthonia.

8. **Billingsites costulatum** (Whiteaves)

Plate XIII, figs. 1 A, B, C

Ascoceras costulatum Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 3, 215, pl. 22, fig. 1 (1897).

Specimen including only the ovoid portion of the conch, formed at its upper end during the gerontic stages of growth of the animal. This ovoid portion, in its present state, is 83 mm. long, has a lateral diameter of 56 mm., and a dorso-ventral one of 34 mm. Originally the dorso-ventral depression of this ovoid part of the conch probably was small, but it evidently was greatly increased by pressure previous to fossilization of the shell. The base of the specimen is formed by a very oblique septum. The concavity of this septum is greatest near the ventral side of the conch, and here was located also the passage of the siphuncle through the septum. The suture of this septum rises from the ventral toward the dorsal side of the specimen at an angle of 55 degrees with the horizontal. At an elevation of 10 mm. above the median part of the ventral outline of this basal septum, the suture of a second septum rises in a dorsad direction, at first at an elevation of 10 degrees with the horizontal, increasing later

to 40 degrees. A short distance dorsad of the median line of the lateral sides of the specimen this suture curves strongly upward and then in a ventrad direction, at the same time dividing into three branches. All of these branches first curve in a ventrad direction, and then change with a broad sweep to a dorsad direction, crossing the dorsal side of the specimen as approximately horizontal lines. The lowest of the three dorsal saddles thus formed attained a height of at least 57 mm. above the base of the specimen. It is estimated that the second dorsal saddle attained a height of about 68 mm., at least dorso-laterally. The third saddle is estimated to have attained a height of at least 74 mm. Only the lateral outlines of these saddles are well preserved. At the maximum lateral diameter of the specimen the transverse ridges ornamenting the surface of the shell are directly transverse, at least along the dorsal half of the conch. At lower levels they slope downward from the dorsal toward the ventral side of the conch. Farther up, they rise in a ventrad direction, so that the ventral margin of the aperture evidently is more elevated than its dorsal margin. Along at least a third of the length of the specimen about 7 of these transverse ridges occur in a length of 10 mm.; lower down this number increases to 9, and near the aperture they apparently occur at the rate of 12 within a corresponding distance. The thickness of the shell varies according to its location. Dorsally it varies from a quarter to half a millimeter in thickness; ventrally it may attain a thickness of nearly 1 mm.

Locality and horizon.—Black island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. No. 7142, Victoria Memorial Museum, Ottawa, Canada.

Remarks.—In structure, this species closely resembles *Billingsites canadensis* (Billings), from the English Head and Vaureal members of the Richmond. However, the change in direction of the basal part of the three conspicuous dorsal saddles, where their sutures are united into a single one, is far less abrupt than in the Anticosti species. The Lake Winnipeg specimen, moreover, is more elongated. The other differences, however, could be due to compression owing to pressure previous to fossilization.

Unfortunately, nothing is known of the character of the ornamentation of the shell of the Anticosti species here named.

In a specimen of *Billingsites* from the Kallholn or Upper Leptaena limestone at Dalbyn in the Dalarne area of central Sweden, the surface of the shell is banded faintly in a transverse direction, as in *Geisonoceras*, the bands or striae curving moderately downward ventrally. Transverse banding occurs also in *Billingsites costulatum*, but in the latter species the bands appear to curve downward dorsally.

ORTHOCERAS Breynius

Genotype: *Orthoceratites* Breynius, Dissert. Phys. Polythalmiis, pp. 12, 19, 31, pl. 3, figs. 1–9 (1732); definitely and clearly figured, but no species name used for the form figured. *Orthoceratites regularis* Schlotheim, Die Petrefactenkunde, 54 (1820); the first species described in accordance with the binomial system, including two types, both preserved in the museum at Berlin. *Orthoceras michelini* Barrande, a form apparently closely similar to the one figured by Breynius, refigured by Hyatt in Zittel-Eastman's Text-book of Paleontology, 599, fig. 1110 (1913).

The specimens figured by Breynius were found in an erratic block of limestone sufficiently large to be quarried for lime, in the vicinity of Dantzig, at the northern end of the corridor of Poland. Their association with *Lituites* indicates that they came from the upper part of the *Orthoceras* limestone of Baltic areas. The types mentioned by Schlotheim in his original description of *Orthoceratites regularis* were stated by him to have been found at Reval and Öland. In the Berlin Museum of Natural History they are labelled as coming from Reval. This suggests their derivation as also being from the *Orthoceras* limestone, mentioned above. Of the two specimens in the Schlotheim collection, one is a phragmacone and the second is a living chamber. The phragmacone is selected here as the type of the species. It retains 7 camerae and also the lower part of an eighth camera. The sutures are transverse. The siphuncle is central in location and its passage through the septa is relatively small. The

rate of enlargement of the conch also is small. The number of camerae in a length equal to the diameter of conch is more nearly similar to that of *Orthoceras intermedium* Marklin, as figured by Hyatt in Zittel-Eastman's Text-book of Paleontology, than to the *Orthoceras michelini* figured in the same publication. The living chamber referred by Schlotheim to *Orthoceratites regularis* enlarges more rapidly than the phragmacone described above and probably belongs to a different species.

9. **Orthoceras** sp. (East Selkirk)

Plate XXII figs. 4 A, B

Specimen 53 mm. long, 30 mm. in diameter at its base, cross-section circular, rate of enlargement very small. Camerae about 14 mm. long. Concavity of septa about 6 mm. Center of siphuncle 11.5 mm. from ventral side of conch. Diameter of siphuncle 4.9 mm., diminishing about half a millimeter at the septal necks. The latter are about 0.6 to 0.8 mm long. The general outline of the segments is almost cylindrical. The surface of the shell is not exposed, but in cross-section it appears to be smooth.

Locality and Horizon.—East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 6016, Victoria Memorial Museum.

CYCLOCERAS M'Coy

Genotype: *Cycloceras laevigatum* M'Coy, Syn. Carb. Foss. Ireland, 10 (1844).

None of the three species placed by M'Coy under *Cycloceras* in the body of his text agree with his description of this genus. However, under the rule that in case no type is mentioned by the author of a genus the type must be sought under those species actually assigned by him to this genus in his original description of the latter, *Cycloceras laevigatum* was selected by Croneis. This is the only one of the three species which M'Coy figured, and in the text he emphasized the reference of this species to *Cycloceras*. But it is well to remember that in none of the species

mentioned by M'Coy is the location of the siphuncle near the wall of the conch, and in none are the transverse striae frequently decussated, as indicated in his original description of the genus. As a matter of fact, M'Coy used the term *Cycloceras* for any orthoconic form which was annulated, as may readily be seen by referring to his British Palaeozoic Fossils, where species of *Dawsonoceras* and *Spyroceras* are included under the same name.

10. **Cycloceras selkirkense** (Whiteaves)

PLATE XXXVII, figs. 4A, B

Orthoceras Selkirkense Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 82, pl. 8, figs. 2, 2a, 2b (1892).

Specimen 60 mm. long, enlarging dorso-ventrally from a diameter of 19 mm. to 20 mm. within a length of 50 mm. The dorso-ventral diameter is estimated to have been 24 mm. at the top of the specimen. Four camerae occur within a length of 55 mm., or approximately one and a half camerae in a length equal to the dorso-ventral diameter of the conch. The sutures of the septa slope moderately downward in a ventrad direction. Their concavity equals almost 4 mm. The center of the siphuncle is located 5 mm. from the ventral wall of the conch. The diameter of the siphuncle at its passage through the septa appears to have been 4 mm., enlarging slightly within the camerae. The exact amount of this enlargement can not be determined in the present condition of the specimen, the central part of the siphuncle having been removed in the process of sectioning, but it is assumed not to have exceeded 1 mm. to any conspicuous degree. The septal necks vary from half to three-quarters of a millimeter in length. The surface of the conch is annulated immediately above each of the sutures. The annulations are 3 mm. wide and from 0.75 to 1 mm. in height. In addition, the surface of the shell is crossed by low and relatively broad raised lines half a millimeter in width, about 5.5 or 5 in a length of 5 mm. The crests of these raised lines are broadly rounded, instead of sharply elevated.

Locality and horizon.—East Selkirk, Manitoba; from the upper or Selkirk member of the Red River formation. No. 1837, Victoria Memorial Museum.

The larger specimen figured by Whiteaves was numbered 1838, but can no longer be found.

Another specimen, referred to the same species, was found in the quarry of the Tyndall Stone Company, at Tyndall, southeast of East Selkirk; in the upper or Selkirk member of the Red River formation.

Remarks.—The specimen here figured and described is selected as the type. It differs conspicuously from typical *Cycloceras* in the relative distance between the annulations, in the inconspicuous and not sharply crested transverse raised lines, and in the ventrad location and large size of its siphuncle.

SPYROCERAS Hyatt

Genotype: *Orthoceras crotalum* Hall, Pal. New York, 5, pt. 2, pls. 42, 82, 113 (1879). *Spyroceras crotalum* Hyatt, Proc. Boston Soc. Nat. Hist. 22, 276 (1884).

In the genotype the conch is crossed transversely by strong, sharply defined, and rather distant annulations. The vertical striae are very fine, almost microscopic, and closely crowded. In the Anticosti Richmond species *Spyroceras microlineatum* Foerste the vertical striae are similarly crowded, and if *Spyroceras aquilonare* (Troedsson), which preceded the Anticosti species in publication, is essentially the same thing, then the vertical striae of the latter must be of the same nature. *Spyroceras fritzi* Foerste may belong to the same division of the genus.

11. Spyroceras cf. aquilonare (Troedsson)

Dawsonoceras aquilonare Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, Cephalopods, 35, pl. 9, figs. 2–4 (1926).

Specimen 90 mm. long, at present 52 mm. in width, but originally at least 60 mm. in diameter, with 7 annulations in a length of 62 mm. These annulations and the intermediate grooves are conspicuous, as in the species cited above. They slope downward across the preserved side of the specimen at an angle of 15 degrees with the horizontal. The sutures of the septa are as numerous as the septa and occur immediately below the crest of

the latter. Not enough of the circumference of the conch is preserved to determine whether the obliquity of the annulations is a specific character or is due to distortion of the conch previous to fossilization.

Locality and horizon.—Commissioner Harbour, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. Victoria Memorial Museum. Collected by D. B. Dowling, No. 21, August 25, 1890.

A second specimen, from the southwest point of Berens Island, also is similar to *Spyroceras aquilonare* (Troedsson), the generic reference of the latter having been changed from *Dawsonoceras* to *Spyroceras*. This specimen is 65 mm. long and 56 mm. in diameter. The annulations and intermediate grooves are conspicuous, but otherwise the specimen furnishes little information. Collected by Alice E. Wilson and Madeleine A. Fritz, in July, 1921.

12. **Spyroceras fritzi** Sp. nov.

Plate XXXVII, fig. 2

Specimen 100 mm. long, enlarging from a lateral diameter of 32 mm. at its base to 41 mm. at a point 68 mm. farther up, the apical angle being 7.5 degrees. The surface of the shell is very strongly annulated, the annulations rising fully 3 mm. above the intermediate grooves. Along the lower part of the specimen 5 annulations occur in a length equal to the diameter of the conch, and the intermediate grooves are wider than the annulations. Along the upper part of the specimen 5.5 annulations occur in a corresponding length, and the grooves there are of about the same width as the annulations. The annulations slope downward from the dorsal toward the ventral side of the conch at an angle of about 6 degrees with the horizontal, but, in addition, there is also a downward flexure of the annulations dorso-laterally, faint on the right side of the specimen, but more distinct on its left side. No other surface markings, either vertical or transverse, can be detected. One septum is exposed at a break between the fourth and fifth annulation from the base of the specimen. Its suture occupies the bottom of the groove intermediate to

these annulations, and is parallel to the latter. The concavity of this septum is about 4 mm., which is relatively small considering the width of the conch at this point. The siphuncle is central in location, and its diameter at its passage through the septum just described is 2.5 mm., enlarging to about 6 mm. within the camera. The limits of only one camera can be determined, and this camera is 9 mm. long. The segment of the siphuncle included within this camera presents a vertically elongated elliptical outline.

Locality and horizon.—Ballhead, Lake Winnipeg, from the lower or Dog Head member of the Red River formation, not far above the Winnipeg sandstone. Specimen No. 6000.

EPHIPPIORTHOCERAS Foerste

Genotype: *Orthoceras formosum* Billings, Geol. Surv. Canada, Rept. of Progress for 1853–56, 317 (1857); *Ephippiorthoceras formosum* Foerste, Geol. Surv. Canada, Memoir 145, 71, pl. 11, fig. 11, also text fig. 7 (1925); Trans. Royal Soc. Canada, 22, sec. 4, 226, pl. 3, figs. 1 A, B, C; 2; 4 A, B (1928).

Conchs orthoconic, with sutures of septa curving distinctly downward laterally, and with the segments of the siphuncle enlarging within the camerae so as to present vertically elliptical or nearly spherical outlines.

13. **Ephippiorthoceras** cf. **formosum** (Billings)

Plate XXXVII, figs. 3 A, B; Plate XXII, figs. 3 A, B

Ephippiorthoceras formosum Foerste, Trans. Royal Soc. Canada, ser. 3, 22, sec. 4, 226, pl. 3, figs. 1 A, B, C; pl. 2, figs. 4 A, B.

Specimen 60 mm. long, its lateral diameter enlarging from 17 mm. at its base to 25 mm. at a point 57 mm. farther up, the apical angle being 9 degrees. The cross-section, apparently, is circular. The number of camerae in a length equal to the diameter of the conch is four and a half. The sutures of the septa curve downward laterally, forming lateral lobes and leaving dorsal and ventral saddles. At the top of the specimen, the downward curvature of the lateral lobes is 4 mm. The septa are strongly concave in

a dorso-ventral direction, but only slightly so in a lateral direction. At the base of the specimen, where its lateral diameter is 17 mm., the center of the siphuncle is 6 mm. from the ventral wall of the conch. At this point the segment of the siphuncle is 4.5 mm. in length and diameter, its general form being nearly spherical. The inner walls of the siphuncle are lined with a thick deposit of calcite. This deposit leaves a central tubular passage which is 1.25 mm. in diameter at mid-height within the camera but narrows at the passage of the siphuncle through the septa. Apparently the surface of the shell was smooth.

Locality and horizon.—Tyndall, southeast of East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 6017, Victoria Memorial Museum.

Remarks.—This Manitoba specimen is closely similar to the first one of the three specimens described by Billings[2] in his original description of *Orthoceras formosum,* the genotype of *Ephippiorthoceras,* from the English Head member of the Richmond group on Anticosti Island. This specimen does not preserve the shell, and hence the character of its surface ornamentation may be different from that of the third specimen described by Billings. It is the latter which has been selected as the type of Billings's species, since the name *formosum* probably was suggested by the surface ornamentation of the shell of this third specimen. Until the surface ornamentation of the Manitoba specimen is known it is useless to identify it definitely with the Anticosti species, though the close similarity of the structure of its interior is highly interesting.

GARRYOCERAS Foerste

Genotype: *Orthoceras semiplanatum* Whiteaves, Royal Soc. Canada, Trans., 9, sec. 4, 81, pl. 8, figs, 3, 3a (1892); *Garryoceras semiplanatum* Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, 42, pl. 11, figs. 7 A, B (1928).

Conchs with the ventral side distinctly convex, the dorsal side strongly flattened, and with the sutures of the septa sloping

[2] Billings, E. Geol. Surv. Canada, Rept. Progress for 1853–56, 317 (1857).

downward from the ventral toward the dorsal side of the conch, curving distinctly downward along the latter side, forming shallow but broad dorsal lobes. The siphuncle is relatively small and is located near the ventral side of the conch. Its general form is cylindrical, as far as can be determined from the single specimen at hand.

14. **Garryoceras semiplanatum** (Whiteaves)

Plate XVI, figs. 3 A, B, C

Orthoceras semiplanatum Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 81, pl. 8, figs. 3, 3a (1892).

Garryoceras semiplanatum Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, 42, pl. 11, figs. 7 A, B.

Specimen 90 mm. long. The living chamber enlarges from a lateral diameter of 29 mm. at its base to 30 mm. at a point 43 mm. farther up. The upper part of the phragmacone, for a length of 16 mm., appears to enlarge at a slightly greater rate. The dorsal side of the conch, for a width of 17 or 18 mm., is distinctly flattened. The lateral sides are strongly rounded. The ventro-lateral sides tend to be somewhat flattened, and the median part of the ventral side is slightly angular, at least along the upper part of the living chamber. The camerae number about 16 in a length equal to the lateral diameter. The sutures of the septa slope distinctly downward along the dorsal side of the conch, forming broad lobes about 2.6 mm. in depth at the top of the phragmacone. Laterally the sutures rise at an angle of 10 degrees above a horizontal plane. Along the median part of the ventral side these sutures tend to be angulate, as far as can be determined in the present state of preservation of the specimen. The siphuncle is slightly over 2 mm. in diameter, and its ventral wall is slightly less than 2 mm. from the ventral wall of the conch. Only its ventral and ventro-lateral sides are well preserved, and these indicate that its segments were cylindrical. At one point there is a diagonal line rising at an angle of 30 degrees above the horizontal from the ventral side of the siphuncle, apparently indicating the course of one of the septa in the immediate vicinity

of the siphuncle. This suggests an invaginating series of segments of the siphuncle, somewhat as in *Murrayoceras* (Pl. XVI, fig. 5).

Locality and horizon.—St. Andrews, Manitoba; in the Selkirk member of the Red River formation. No. 1834, Victoria Memorial Museum, Ottawa, Canada.

Remarks.—In general appearance this specimen closely resembles *Kindleoceras reversatum* Foerste (pl. XVI, fig. 4), from the lower part of the Richmond group of strata, at Clay Cliffs, on the eastern margin of Manitoulin island. It differs chiefly in the cylindrical character of its siphuncle, the siphuncle of *Kindleoceras reversatum* being nummuloidal. Exteriorly, *Garryoceras semiplanatum* resembles also *Murrayoceras murrayi*, from the Black River formation of St. Joseph island, in the northwestern part of Lake Huron. Moreover, the structure of its siphuncle appears to have been similar. However, this siphuncle is located on the convex side of the conch in *Garryoceras*, while it is on the flattened side in *Murrayoceras*.

WHITEAVESITES Gen. Nov.

Genotype: *Orthoceras winnipegense* Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 82, pl. 8, figs. 4, 4a, 4b (1892). *Whiteavesites winnipegensis* Foerste, Jour. Sci. Lab. Denison Univ., 24, 29 (1929).

Conch slightly curved lengthwise, with the ventral outline convex. The living chamber contracts upward along its lower half, and then remains of about the same diameter as far as the aperture. The sutures of the septa curve strongly downward laterally, forming broad dorsal and ventral saddles. The septa are strongly concave dorso-ventrally, but only moderately concave laterally. The siphuncle is located a short distance ventrad of the center of the conch. The segments of the siphuncle are elongated vertically in a narrowly elliptical manner.

15. **Whiteavesites winnipegensis** (Whiteaves)

Plate XIII, fig. 3; Plate XIV, figs. 1 A, B; Plate XXVI, fig. 2

Orthoceras Winnipegense Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 82, pl. 8, figs. 4, 4a, 4b (1892).

Specimen 170 mm. long, general outline apparently elongated poterioceroid, its maximum diameter being between 10 and 15 mm. beneath the base of the living chamber. The conch apparently is slightly curved lengthwise, with its ventral side slightly convex, and its dorsal side slightly gibbous at the top of the phragmacone and the base of the living chamber; but the specimen is too badly weathered to admit of the determination of the exact amount of its lengthwise curvature. The conch is depressed dorso-ventrally, its dorso-ventral diameter at 10 mm. beneath the living chamber being estimated at 33 mm., while its lateral diameter is 37 mm. The cross-section of the conch here is sub-quadrangular, its transverse curvature being greatest ventro-laterally, next greatest dorso-laterally, and least along its dorsal, ventral, and lateral sides. The slightly flattened lateral sides converge slightly in a dorsad direction. The lateral outlines of the conch are shown by figure 4 published by Whiteaves. The lateral diameter diminishes from 37 mm. at 10 mm. beneath the base of the living chamber to 30 mm. at a point 35 mm. above this base, and then increases to 33 mm. at the top of the specimen, 30 mm. farther up. The corresponding three dorso-ventral diameters are estimated at 33 mm., 26 mm., and 22 mm. Along the upper half of the living chamber the dorsal part of its cross-section is broadly rounded, while its ventral outline is more distinctly flattened. The thickness of the shell increases from half a millimeter at the top of the phragmacone to 1.3 mm. along the upper half of the living chamber. The number of camerae in a length equal to the dorso-ventral diameter of the conch equals 4. The sutures of the septa curve strongly downward laterally, leaving prominent dorsal and ventral saddles, the former rising slightly higher than the latter. The dorsal saddles are broadly convex. This may have been the form also of the ventral saddles, but, in the present weathered condition of the specimen, the sutures of these saddles curve slightly downward along their medial parts. The siphuncle is located dorsad of the center of the conch, its center, at the maximum diameter of the conch, being 12 mm. from the dorsal side of the conch and 21 mm. from its ventral side. At the top of the phragmacone, where the

length of the camerae is 8 mm., the diameter of the siphuncle at its passage through the septa is almost 2 mm., enlarging to 3 mm. at midheight within the camerae. The septal necks appear to be about 0.5 mm. in length, being slightly shorter on the ventral than on the dorsal side of the siphuncle. The curvature of the septa is much greater in a dorso-ventral direction than laterally. The surface of the shell appears to have been smooth.

Locality and horizon.—Black island, Swampy harbour, Lake Winnipeg; from the Dog Head member of the Red River formation. No. 1830, Victoria Memorial Museum, Ottawa, Canada.

DOWLINGOCERAS Foerste

Genotype: *Poterioceras gracile* Whiteaves, Royal Soc. Canada, Trans., 9, sec. 4, 87, pl. 11, figs. 4, 4a, 4b (1892); *Dowlingoceras gracile* Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, 43, pl. 1, fig. 5; pl. 3, figs. 2 A, B (1928).

Conch somewhat similar to *Diestoceras* in form, but more slender, and much more compressed laterally. The siphuncle moreover is much smaller. It is located near one of the narrower sides of the conch, and its segments enlarge but slightly within the camerae.

In the Geologic Museum at Oslo, Norway, there are several specimens of narrow, laterally compressed conchs in which the transverse striae on the surface of the shell curve distinctly downward on the ventral side of the conch. One of these specimens is from N. Langö, and the other is from Lindöen, and both are from the Chasmops zone in the Isotelus series. A similar form occurs in the Ringerike area, associated with *Discoceras antiquissimum* Eichwald, in the upper part of the Ordovician. This form is moderately compressed laterally, the siphuncle being located near its ventral side. However, in the absence of any definite knowledge of the structure of their siphuncles, it is impossible to assert that any of these specimens are congeneric with the genus *Dowlingoceras*.

16. **Dowlingoceras gracile** (Whiteaves)

Plate XIII, fig. 2 A, B, C

Poterioceras gracile Whiteaves, Trans. Royal Soc. Canada, 9, ser. 4, 87, pl. 11, figs. 4, 4a, 4b (1892).

Dowlingoceras gracile Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, no. 3, 43, pl. 1, fig. 5; pl. 3, figs. 2A, B (1928).

Specimen 85 mm. long. Both its dorsal and its ventral outlines are gently convex. Its dorso-ventral diameter enlarges from 11 mm. at the lower end of the specimen to 32 mm. at the top of the phragmacone and then diminishes to about 30 mm. at the aperture of the living chamber. Between 8 and 10 mm. beneath this aperture the dorso-ventral diameter of the cast of the interior of the conch contracts to 28 mm., evidently owing to an annular thickening of the interior of the shell. In a lateral direction the diameter of the conch increases from 6.5 mm. at its base to 19 mm. at the top of the phragmacone, and then diminishes to 15 mm. at the aperture of the living chamber. The cast of the interior of the conch is at least half a millimeter narrower at 10 mm. beneath the margin of the aperture, where the annular thickening of the interior of the shell was located. The conch evidently has been compressed laterally by pressure previous to fossilization, so that its original maximum lateral diameter may have equalled approximately 22 or 23 mm. The number of camerae in a length equal to the dorso-ventral diameter of the conch at the top of the series counted equals at least 11. The sutures of the septa curve distinctly downward laterally, leaving dorsal and ventral saddles. The amount of this downward curvature equals about 3 mm. Where the dorso-ventral diameter of the conch is 29 mm., the segments of the siphuncle are 3 mm. in length, and 1.9 mm. in diameter at mid-length. They are conspicuously contracted at the septal necks, which are about 0.75 mm. long and 1 mm. in diameter, as far as can be determined from their exposure at present, due to grinding away a part of the ventral side of the specimen. The surface of the shell is distinctly ornamented by low, broad, gently rounded, raised, transverse lines, about half a millimeter in width, nearly 6 of

these lines occurring in a length of 5 mm. between 25 and 30 mm. beneath the base of the living chamber. Along the lower half of this chamber the surface of the shell was almost smooth, only very minute and closely arranged sharply defined lines being visible.

Locality and horizon.—Black island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. No. 1841, Victoria Memorial Museum, Ottawa, Canada.

CHARACTOCERAS Foerste

Genotype: *Trochoceras* (?) *baeri* Meek and Worthen, Proc. Acad. Nat. Sci. Philadelphia, 263 (1865); Meek, Geol. Surv. Ohio, Pal., 1, 157, pl. 13, fig. 9 (1873). *Charactoceras baeri* Foerste, Jour. Sci. Lab. Denison Univ., 20, 235, pls. 31–34 (1924).

Conch nautiloid, depressed dorso-ventrally, with a distinct dorsal impressed zone. The transverse striae on the surface of the shell indicate that the hyponomic sinus was broad and relatively deep, but not abrupt. The sutures of the septa curve slightly downward laterally, rising higher ventrally than dorsally. The siphuncle is located near the ventral side of the conch, but not near contact with the latter. The segments of the siphuncle enlarge but moderately within the camerae, presenting elliptical outlines elongated in a direction parallel to the central axis of the conch.

17. Charactoceras (?) plicatum (Whiteaves)

Plate XV, figs. 1 A, B, C; Plate XVI, figs. 1, 2

Eurystomites plicatus Whiteaves, Pal. Foss., Geol. Surv. Canada 3, pt. 3, 225, figs. 15, 16; pl. 22, fig. 2 (1897).

Type.—This specimen is strongly depressed in a direction dorso-ventral to the lower half of the living chamber. It consists of the anterior half of the outer volution of the conch and of the adjoining part of the next inner volution, the ventral side of the latter being in contact with the impressed zone along the dorsal side of the former. The outer volution is represented by most of the living chamber, and by 4 distinctly defined camerae. The maximum diameter of the conch, from the upper end of the

living chamber across the umbilical opening, is estimated to have been at least 112 mm. In its present condition the lateral diameter enlarges from 58 mm. at a point 5 camerae back from the base of the living chamber to 87 mm. at its larger end. The coiling is nautiloid, the dorsal side of the conch being deeply and broadly impressed where in contact with the ventral side of the preceding volution. Where the lateral diameter of the living chamber is 75 mm., the width of this impressed dorsal zone is about 30 mm., and its depth is about 5 or 6 mm. The cross-section of the conch evidently was depressed dorso-ventrally. At the point where this depression was least altered by the distortion of the conch previous to fossilization its dorso-ventral diameter is 30 mm., in contrast with the lateral diameter of approximately 58 mm. At the base of the living chamber the lateral diameter is about 67 mm. Beneath this point 4 camerae occupy a length of 28 mm., suggesting about 10 camerae in a length equal to the lateral diameter of the conch, when counted along its ventral outline. The sutures of the septa curve downward ventrally about 5 mm; they curve downward also within the dorsal impressed zone. The septa are moderately concave in a lateral direction, but more strongly concave dorso-ventrally. At the base of the fourth camera beneath the living chamber, where the dorso-ventral diameter is 30 mm., the center of the siphuncle is 8 mm. from the ventral wall of the conch; its passage through the septum is 2 mm. in diameter, and it enlarges within the camerae to 3 mm. The segments of the siphuncle are about 6 mm. long, and their vertical outline is elliptical-oblong. The length of the septal necks is almost 1 mm. on that side of the siphuncle which faces the interior of the conch and slightly more than 1 mm. on its ventral side. The shell is almost 1 mm. thick along the living chamber. Its surface is distinctly ribbed transversely. These ribs are most distinct dorso-laterally, become weaker along the middle of the lateral sides, and disappear altogether ventro-laterally. They become faint also laterally on approaching the upper part of the living chamber. In addition to the ribs there also are transverse striae or narrow bands, parallel to the ribs. These continue their course across the ventral parts of the shell,

where the ribs are absent. The transverse ribs and striae curve increasingly downward from the dorso-lateral toward the ventro-lateral parts of the shell, forming relatively deep and broad ventral lobes. About 6 striae occur in a length of 5 mm. along the ventral side of the living chamber. The cast of the interior of the conch shows little or no trace of ribbing or striation. Plate XV, figs. 1A, B, C.

Locality and horizon.—Black Island, Swampy Harbour, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. No. 7155, Victoria Memorial Museum.

In addition to the type, just described, the following two specimens are referred provisionally to the same species, *Charactoceras plicatum*. Nothing is known of their interior structure, but the median part of the dorsal side of the conch is strongly impressed. The transverse ribs are best developed dorso-laterally, become weaker ventro-laterally, and disappear along the median part of the ventral side. All of the ribs appear to disappear along the upper part of the living chamber of the larger specimen.

East Selkirk specimen.—The conch is 106 mm. in maximum diameter, measured across the umbilical area. That part of the last volution which remains is 285 mm. in length, measured along the ventral outline of the conch, and of this length 90 mm. belongs to the lower part of the living chamber, the aperture of the latter not being preserved. At the base of the living chamber the dorso-ventral diameter is 48 mm., the lateral diameter being estimated at 60 mm. One volution back from the larger end of the specimen the dorso-ventral diameter of the conch is estimated at 20 mm. At the larger end of the living chamber the contact groove, on the dorsal side of the conch, is estimated to have a width of approximately 30 mm., and a depth of about 5 mm.; however, the actual area of contact probably is only 25 mm. wide. A little more than half the diameter of the inner volution is exposed here on lateral view. However, still less is exposed half a volution farther back, where only about one-fourth of the dorso-ventral diameter of the conch appears to be visible on lateral view, this small exposure continuing for at least three-fourths of a volution in an apicad direction, beyond which the

earlier formed parts of the conch are not preserved. Two camerae are outlined at the top of the phragmacone, of which the upper one is 2.5 mm., and the lower one is 3 mm. in length. The concavity of the septa here is nearly 10 mm. The siphuncle is not exposed. The thickness of the shell is estimated at 1.5 mm. along the upper part of the living chamber. Along the more apicad parts of the conch the surface of the shell is ribbed conspicuously in a transverse direction along the dorso-lateral parts of the conch. These ribs disappear ventro-laterally, and become weaker also on approaching the larger end of the phragmacone. Apparently they are obsolete along the living chamber. Where the dorso-ventral diameter of the conch is 26 mm., 5 of these ribs occupy a corresponding length, when these ribs are counted along the ventral outline. In addition to the ribs, there are transverse striae, parallel to the ribs. These striae continue their course across the ventral side of the conch, where the transverse ribs are absent. Ten or eleven striae occur here in a length of 10 mm. The ribs and striae curve increasingly downward from the dorso-lateral toward the ventro-lateral parts of the conch, and indicate the former presence of a relatively deep and broad hyponomic sinus. This specimen was found at East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 7160, Victoria Memorial Museum. Plate XVI, fig. 1.

Beren Island specimen.—Specimen evidently belonging to the same species as the preceding one from East Selkirk, having transverse ribs and striae of equal size, prominence, and distribution. Its maximum diameter across the umbilical area is 63 mm. At its larger end the dorso-ventral diameter is 32 mm., and the lateral one is at least 30 mm., but the conch may have been compressed laterally. The dorsal impressed zone here is about 15 mm. wide and nearly 10 mm. deep. Where the dorso-ventral diameter is 15 mm., 3.5 camerae occupy a corresponding length, when counted along the ventral outline. The specimen apparently was compressed laterally previous to fossilization, but at present the sutures of the septa curve downward laterally and cross the ventral side of the conch more or less directly. This specimen was found on the east side of Berens Island, Lake

Winnipeg, in the Dog Head member of the Red River formation. No. 7159, Victoria Memorial Museum. Plate XVI, fig. 2.

18. **Charactoceras** (?) **schucherti** Foerste

Charactoceras schucherti Foerste, Jour. Sci. Lab. Denison Univ., 23, 61, pl. 9, figs. 2 A, B, C; pl. 27, figs. 4 A–D (1928).

This species is regarded as congeneric with the one described by Whiteaves under the name *Eurystomites plicatus*, and referred here to *Charactoceras*, though doubtfully. Compared with the latter, it has a similar small enlargement of the segments of the siphuncle within the camerae. However, only the cast of the interior of the conch of *Charactoceras schucherti* is preserved, and in the absence of any knowledge of the surface of the shell it can not be determined whether the surface of the shell was transversely ribbed, at least along the dorso-lateral parts of the conch, as in *Charactoceras plicatum*, nor is anything known of the presence of transverse striae. Apparently, the cast of the interior of *Charactoceras schucherti* is smooth, while that of *Charactoceras plicatum* is distinctly though only moderately ribbed along its dorso-lateral parts. *Charactoceras schucherti* was found at the head of Frobisher bay, in the southeastern part of Baffin Land. Specimen No. 28123, U. S. National Museum.

In typical *Charactoceras*, the surface of the shell is transversly striated, but no transverse ribs are present. *Charactoceras plicatum*, on the contrary, appears to have been derived from an ancestor which was distinctly ribbed transversely, and ribs are still present, though best developed at younger stages of growth, apparently becoming more or less obsolete along the upper part of the living chamber. The presence of these ribs suggests that possibly *Charactoceras plicatum* is distinct generically from typical *Charactoceras*, but the evidence is not clear, and therefore no new name is proposed. However, the relationship of *Charactoceras schucherti* appears to be with *Charactoceras plicatum*, rather than with the genotype *Charactoceras baeri* (Meek and Worthen).

DISCOCERAS Barrande

Genotype: *Clymenia antiquissima* Eichwald, Die Urwelt Russlands, 2, 33, pl. 3, figs. 16, 17 (1842); Lethaea Rossica, 1, 1301 (1860).

Discoceras antiquissimum Barrande, Systeme Silurien du Centre de la Boheme, 2, Distribution horizontale et verticale des Cephalopodes, 37 (1870); also vol. 2, pt. 4, 62 (1800); Foerste, Jour. Sci. Lab. Denison Univ., 21, 58, pl. 18, figs. 1A,B (1925).

The Geological Museum at Oslo, Norway, contains three species of *Discoceras*, including representatives of the type species, *Discoceras antiquissimum*. The latter is characterized by the presence of ribs which curve strongly downward ventrally, indicating that the hyponomic sinus at different stages of growth had been deep and acutely V-shaped, as in the figure published by Eichwald, and republished by Foerste, as cited above. These ribs are bold ventrally and ventro-laterally, but become less prominent dorso-laterally.

The second and more common species had a broader and less acute base along the hyponomic sinus. The transverse striae are numerous and tend to group into elevated clusters or ribs at regular intervals. These ribs are more numerous and less conspicious than in the type species, especially laterally.

The third species has transverse ribs which are elevated in a knob-like manner at the ventro-lateral angles of about every third camera, but these ribs tend to disappear ventrally and laterally.

All three species came from the Ringerike area southwest of Oslo, in Norway, and all present the same type of structure, though it so happens that the following notes were taken from a specimen belonging to the second species as here listed.

Conch attaining a total diameter of 250 mm. across the umbilical depression. At about one-fourth of a volution back from the base of the living chamber the dorso-ventral diameter of the conch is 22 mm., and the lateral one equals 30 mm. The cross-section of the conch (pl. XX, fig. 2) is somewhat quadrangular, the ventral and lateral sides being distinctly flattened. The

ventral sides converge moderately in a dorsad direction. The impressed zone of the dorsal side is 14 mm. wide and about 1 mm. deep. The sutures of the septa curve downward laterally and ventrally, leaving distinct ventro-lateral saddles. The siphuncle is 1 mm. from contact with the dorsal wall of the conch. Its diameter at the septal necks is 5 mm. The segments of the siphuncle enlarge moderately within the camerae.

The species described by Whiteaves under the name *Discoceras canadense* agrees with typical *Discoceras* only in the dorsad location of the siphuncle and in the course of the ribs ornamenting the surface of the shell. In other respects it is so different that it probably belongs to a distinct genus. The siphuncle is relatively much smaller. The cross-section of the conch is not quadrangular. The ventral and lateral sides are not distinctly flattened, nor do these lateral sides converge in a dorsad direction. There is no dorsal impressed zone, and there is no evidence of a downward curvature of the sutures of the septa along the ventral side of the conch. However, both specimens of the Manitoba species found so far appear to be compressed laterally, and their state of preservation is scarcely good enough to warrant their use as types of a new genus.

19. **Discoceras canadense** Whiteaves

Plate XVII, figs. 1 A, B; 2

Discoceras Canadense Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 3, 227, pl. 22, figs. 3, 3a (1897).

Conch nautiloid. The maximum diameter of the outer volution across the umbilical area is 67 mm.; the corresponding diameters of the next two volutions are 31 mm. and 15 mm., counting from the outer volution toward the center. The apical part of the specimen is not preserved; the missing part probably included at least half a volution. That part of the specimen regarded as belonging to the living chamber is 85 mm. long, measured along its convexly curved outline. Only one septum is exposed, and that is the one at the base of the living chamber. At this point, the dorso-ventral diameter of the last whorl is

15 mm., and its lateral diameter is 14 mm. However, the conch appears to have been compressed laterally by pressure before fossilization, but the amount of this compression is unknown. At present, the cross-section of the last whorl is elliptical in outline, but the regularity of this outline is interrupted along the dorsal side of the whorl, where the latter is flattened or faintly concave for a width of about 8 mm. The suture of the septum at the base of the living chamber curves distinctly downward laterally for a distance of at least 2 mm., leaving dorsal and ventral saddles. At this point, where the dorso-ventral diameter of the whorl is 15 mm., the siphuncle is 1.25 mm. in diameter, and its center is 2 mm. from the dorsal or concave side of the conch. At a transverse fracture of the conch, 38 mm. back from the base of the living chamber, measured along the convex side of the conch, the conch is badly flattened laterally. In its present condition, the dorso-ventral diameter is 16 mm., the siphuncle is slightly over 1 mm. in diameter in the same direction, but narrower laterally, and its center is about 2 mm. from the dorsal side of the conch, the location of the latter not being clearly defined. At 78 mm. back from the base of the living chamber, measured along the ventral side of the conch, the dorso-ventral diameter of the conch is 12.5 mm., the corresponding diameter of the siphuncle is 1.1 mm., and its center is located 3 mm. from the dorsal wall of the conch. At a point 110 mm. back from the base of the living chamber, where the dorso-ventral diameter of the conch is 11 mm., the corresponding diameter of the siphuncle is about 1 mm., and its center is about 3 mm. from the dorsal wall of the conch. This fourth exposure of the siphuncle is along a transverse fracture three-quarters of a volution back from the base of the living chamber. A last glimpse of the siphuncle is seen half a volution farther back, between the transverse fracture at the base of the living chamber and the one next beneath, already mentioned in the preceding description of exposures of the siphuncle. The shell appears to be thick. Its surface is strongly ribbed, the ribs curving moderately downward from the dorso-lateral to the ventro-lateral sides of the conch, but strongly downward ventrally. They are strongly prominent along their

entire course, especially ventro-laterally. Three ribs occur in a length equal to the dorso-ventral diameter, when counted along the ventral side of the conch. In addition to the ribs, there are transverse striae parallel to the ribs, about 8 in a length of 2 mm. along the ventro-lateral parts of the conch about a third of a volution back from the base of the living chamber. The ribs are distinct for about one and a half volutions back from the base of the living chamber. Beyond this point they either become faint or are not well preserved.

Locality and Horizon.—Commissioners Harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. No. 7157, Victoria Memorial Museum, Ottawa, Canada.

Remarks.—Compared with *Discoceras antiquissimum* (Eichwald), the genotype of *Discoceras*, this Manitoba specimen is similar in the dorsal location of its siphuncle, in the prominence and curvature of its transverse ribs; in the relatively acute hyponomic sinus indicated by the course of these ribs along the median part of the ventral side of the conch; and in the general rate of enlargement of the conch. It differs, however, conspicuously in the much smaller size of its siphuncle compared with the dorso-ventral diameter of the conch; in the relatively more distant location of this siphuncle from the dorsal wall of the conch; in the absence of ventral lobes along the sutures of the septa, and in the much smaller size of the conch. Moreover, it is doubtful from the specimen at hand whether in the Manitoba specimen the lateral diameter is conspicuously broader than the dorso-ventral one, whether the lateral sides converge distinctly in a dorsad direction, and whether the dorsal contact zone is as conspicuously concave as in typical *Discoceras antiquissiumum*. It will require better preserved specimens of the Manitoba species to determine whether this species *Discoceras canadense* is to be retained in the genus *Discoceras*, or not. Provisionally, however, this appears to be its best location, in view of the dorsal location of its siphuncle, and the prominence and course of its transverse ribs.

Swampy Island specimen.—Specimen 72 mm. in diameter across the umbilical area, consisting of at least three and a half

volutions. The dorso-ventral diameter of the last volution is about 21 mm. at its larger end, the corresponding lateral diameter being 17 mm. Of the living chamber a length of 50 mm. remains, there being a trace of the septum at its base. The transverse ribs are like those of the preceding specimen. They are prominent ventrally as well as laterally, and the hyponomic sinus, as indicated by these ribs, was angularly and rather narrowly V-shaped. This specimen is numbered 7158, and was collected by J. B. Tyrrell on Swampy Island, at station No. 15, on May 30, 1889.

WILSONOCERAS Gen. Nov.

Genotype: *Trochoceras mccharlesi* Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 81, pl. 16, figs. 1, 2 (1890). *Wilsonoceras mccharlesi* Foerste, Jour. Sci. Lab. Denison Univ., 24, 29 (1929).

Conch large, with the volutions of the phragmacone apparently in contact with each other, at least at some of the earlier stages of growth. At later stages, the living chamber becomes free from the preceding volutions. Cross-section circular, with an impressed zone along the dorsal side of the phragmacone, where in contact with preceding volutions. In the type of the specimen described as *Apsidoceras insigne*, this dorsal impressed zone extends as far up as the lower part of the living chamber. The sutures of the septa curve slightly downward laterally, rise into low saddles ventro-laterally, and curve strongly downward ventrally. The siphuncle is located ventrad of the center of the conch. It is relatively large in size, and enlarges within the camerae, but not sufficiently to be called nummuloidal. Named in honor of Alice E. Wilson.

20. **Wilsonoceras mccharlesi** (Whiteaves)

Plate XIX, XX, XXI, XXII, XXIII

Trochoceras McCharlesi Whiteaves, Trans. Royal Soc. Canada. 7, sec. 4, 81, pl. 16, figs. 1, 2 (1899).

Apsidoceras insigne Whiteaves, ibid., 82, pl. 17, figs. 1, 2 (1889).

Type.—Approximately half of a phragmacone. All of the living chamber and the upper end of the phragmacone are missing.

The specimen consists of half of the remainder of the phragmacone, the latter having split across the umbilical opening. The maximum diameter of the larger one of the volutions preserved, measured across this umbilical opening, was 265 mm. The dorso-ventral diameter of the conch at the larger end of this volution is 100 mm.; half a volution or 395 mm. back from this larger end, when measured along the ventral outline of the conch, this diameter is 66 mm.; and another half volution or about 265 mm. farther back this diameter is 30 mm. The cross-section of the conch is nearly circular, the lateral diameter apparently slightly exceeding the dorso-ventral one, the difference equalling only a few millimeters at the larger end of the specimen. The larger end of the specimen evidently was free from contact with the preceding volution, being separated from the latter by a distance of 10 mm. There may have been contact, however, at earlier stages of growth. There is no evidence of a trochoceroid form of coiling, such as that indicated by figure 2 on plate 16 published by Whiteaves, as cited above. This figure was based on the appearance of the specimen in the condition in which it was left by the cleaner, but on securing a fresh surface along the area of fracture by filing away the old surface it was found that there was no definite trace here of more than three cross-sections of the conch, corresponding to the upper two and the lower one of the circles forming Whiteaves's figure 2. It will be noted that these three circles lie in the same plane, and therefore show no trochoceroid form of coiling. The number of camerae in a length equal to the dorso-ventral diameter of the conch equals about 3.75 along the lower two-fifths of the larger half volution forming the specimen, changing to 4.6 along its upper part. The sutures of the septa curve downward about 10 or 11 mm. along the ventral side of the conch where its diameter is 85 mm.; along the ventro-lateral sides of the conch they form low saddles; along its lateral sides they are not exposed. No trace of the siphuncle is preserved. The shell is thick, varying from 1.5 to 2 mm. in thickness in different parts of the specimen. Its surface is marked by narrow transverse ribs which number about 16 or 17 in a length of 50 mm. along the lower part of the larger half

volution making up the greater part of the specimen, increasing to 20 or 21 in a corresponding length at its upper or larger end. The crest of these ribs is rounded and is located nearer their upper margin, as in some forms of *Geisonoceras*. These ribs curve downward more strongly than the sutures of the septa, their downward curvature beginning along the dorso-lateral sides of the conch and becoming strongest ventro-laterally. Between the middle of the ventro-lateral sides of the conch and the middle of the ventral side these ribs curve downward 25 mm. where the corresponding downward curvature of the sutures of the septa is only 10 or 11 mm. There are no transverse striae in addition to the transverse ribs. Fig. 1, on Plates XIX, XX.

Locality and horizon.—East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 1873, Victoria Memorial Museum.

Second specimen.—Specimen preserving one and a half volutions, including a considerable part of the living chamber, but not the earlier stages of growth of the phragmacone. Maximum diameter of conch, from the ventral side of upper extremity of that part of the living chamber which is preserved to the ventral side on the opposite part of the last volution, 435 mm.; diameter of the last volution at right angles to the maximum diameter, 340 mm. The total length of the last volution, measured along the ventral side of the conch, is 1080 mm.; of this length, 320 mm. belongs to the living chamber. The maximum diameter of the second last volution is 185 mm., and the diameter at right angles with the latter is 150 mm. The total length of this volution was originally about 465 mm., but of this length only the upper part, 310 mm. long, remains. The outer volution was in contact with the next inner one for almost the entire length of the phragmacone, but became free at the base of the living chamber, or possibly several centimeters below the base of the latter. The upper part of the living chamber straightens out, so that at 225 mm. from the base of this chamber its dorsal side is at least 40 mm. from the nearest part of the preceding volution. The dorso-ventral diameter of the conch is 118 mm. at a point 200 mm. beneath the base of the living chamber, measured along the ventral

side of the conch. At this point the cross-section of the last volution of the conch is distinctly depressed dorso-ventrally, the lateral diameter being 133 mm., and the cross-section transversely elliptical, but with its maximum width slightly ventrad of the center of the conch. The ventral side of the conch here is distinctly convex, and a similar convexity is presented by the ventral part of cross-sections at earlier stages of growth; but along the top of the phragmacone, for a length of 135 mm., and along the living chamber the median part of the ventral side is distinctly flattened. This flattening may not be characteristic of the species but only of this individual, since the change from a convex ventral cross-section to a flattened one takes place suddenly, accompanied by a shortening of the dorso-ventral diameter, as though due to an injury to the shell at the beginning of its flattened part. The conch enlarges more rapidly at the earlier stages of growth than later, as is indicated by the following measurements. At the smaller end of the specimen its dorso-ventral diameter is 35 mm., enlarging at successive stages of 30 mm. to 75 mm., 102 mm., and 118 mm., above which the flattening of the venter begins; the dorso-ventral diameter at the next interval of 30 mm. being still 118 mm. Between 300 and 400 mm. beneath the base of the living chamber, 6 camerae occur in a length equal to the dorso-ventral diameter of the conch, when counted along its ventral outline; in a corresponding length at the top of the phragmacone there are 8 camerae. The sutures of the septa are almost straight along the lateral sides of the conch or curve slightly downward. Ventro-laterally, the sutures rise slightly, forming low saddles. However, along the ventral side of the conch they curve strongly downward, forming broad lobes which are fully 15 mm. in depth along the upper part of the phragmacone. At a point about 250 mm. beneath the base of the living chamber, where the dorso-ventral diameter of the conch is 103 mm. and its lateral diameter is about 118 or 120 mm., the concavity of the septa equals 25 mm. The center of the passage of the siphuncle through the septum here is 35 mm. from the dorsal wall of the conch; this equals about one-third of the length of the dorso-ventral diameter of the conch. The dorso-

ventral diameter of the passage of the siphuncle through the septum at the same place equals 19 mm., and its lateral diameter is 14 mm.

Locality and horizon.—Tyndall, Manitoba; from the upper or Selkirk member of the Red River formation. Specimen No. 6018, Victoria Memorial Museum. Plate XXIII.

Apsidoceras insigne.—The type of *Apsidoceras insigne* bears no close resemblance to that of *Trochoceras mccharlesi.* In the type of *Trochoceras mccharlesi* the cross-section of the conch is circular, the volutions are not in contact with each other, and, of course, there is no dorsal impressed zone. In the type of *Apsidoceras insigne,* on the contrary, the ventral side of the conch is distinctly flattened, and there is a distinct dorsal impressed zone, indicating that the last volution had been in contact with the preceding volution at a point about 120 mm. back from the base of the living chamber. In both types the sutures of the septa curve strongly downward ventrally, but the median part of the resulting ventral lobes appears distinctly angular in the type of *Apsidoceras insigne,* while the ventral lobes of *Trochoceras mccharlesi* are more evenly rounded. Neither type presents any trace of the location of the siphuncle. Under these circumstances, the reference of the two types here considered to two distinct species, and even to two genera, was natural, especially in view of the fact that the cross-section of the species described as *Apsidoceras insigne* was similar to that of *Apsidoceras magnificum,* a well-known Anticosti species.

Moreover, in the type of *Apsidoceras insigne* the camerae are relatively more numerous in a length equal to the dorso-ventral diameter of the conch, when these camerae are counted along the ventral outline of the conch. This is true also of the additional specimens of *Apsidoceras insigne* found since the type was described.

However, the large specimen of *Trochoceras mccharlesi* from Tyndall described in the preceding lines indicates similarities where none were suspected before. A quarter of a volution back from the base of the living chamber the dorso-ventral diameter of the conch is 104 mm. while its lateral diameter is 122 mm.

The ventral side of the cross-section is distinctly less curved than the lateral sides, and this ventral side moreover is distinctly broader than the dorsal side of the cross-section. On approaching the living chamber, however, this ventral side becomes distinctly flattened, in a manner very similar to that of *Apsidoceras insigne*. Moreover, the course of the sutures of the septa in the large specimen of *Trochoceras mccharlesi* was found to be similar to that of the sutures in *Apsidoceras insigne*. On exposing the sutures on the ventro-lateral parts of the type of *Trochoceras mccharlesi*, the latter also were found to agree in direction. Finally, in the large specimen of *Trochoceras mccharlesi* the number of camerae in a length equal to the diameter of the conch was found to be intermediate between those in the type of *Trochoceras mccharlesi* and those in the type of *Apsidoceras insigne*. The type of *Trochoceras mccharlesi* evidently represents an earlier stage of growth. As to the dorsal impressed gone in *Apsidoceras insigne*, the upper part of the last volution of the large specimen of *Trochoceras mccharlesi* appears to have been in contact with the ventral side of the preceding volution sufficiently to have produced a faint impression along the median line of its dorsal side, so that other specimens might have had a more conspicuous dorsal impressed zone.

While the preceding observations do not definitely prove that *Apsidoceras insigne* belongs to the same species as *Trochoceras mccharlesi*, they leave us without any definite means of discriminating between the two. Therefore, *Apsidoceras insigne* is referred provisionally to *Trochoceras mccharlesi*, as least until something is known of the location, size, and structure of its siphuncle.

Type of *Apsidoceras insigne*.—Fragment 45 mm. long, measured along its ventral outline and the extension of the latter. Of this length 120 mm. belongs to the lower end of the living chamber. At the base of this chamber its dorso-ventral diameter is 125 mm. and its lateral diameter is estimated at 160 mm., but it may be less. The dorso-ventral diameter diminishes to about 110 mm. at a point 260 mm. back from the base of the living chamber. The ventral side of the conch is distinctly flattened along that

part of the chamber which is preserved, the incipient stages of this flattening being evident along the upper part of the phragmacone. Along the lower part of that portion of the phragmacone which is preserved the dorsal impressed zone is estimated to have been 40 mm. wide and between 3 and 5 mm. deep. This impressed zone evidently disappeared gradually toward the top of the specimen. The number of camerae in a length equal to the dorso-ventral diameter of the conch is 9 when counted along the ventral outline of the upper part of the phragmacone. It diminishes to 7 camerae along the lower part of the specimen, and may have been less along earlier formed parts of the conch. The sutures of the septa curve slightly downward laterally, rise slightly toward the ventro-lateral angles of the conch, and then curve strongly downward ventrally, with a tendency toward angulation along the median part of their ventral course.

Locality and horizon.—Stony Mountain, Manitoba; in the Stony Mountain member of the Richmond group. Specimen No. 2217, Victoria Memorial Museum. Plate XXI; pl, XXII, fig. 1.

The matrix of this type includes a well preserved ventral valve of the large rhynchonelloid usually identified as *Rhynchotrema perlamellosum.* Along the lower part of the living chamber there is a thin film of an incrusting fossil resembling *Protaraea richmondensis papillata* Foerste, but apparently with broader interspaces between the round depressions or so-called corallites. In structure these Richmond forms of *Protaraea* suggest stromatoporoids rather than corals. In the memoir on the Upper Ordovician Faunas of Ontario and Quebec,[3] *Protaraea* was associated with *Stromatocerium* and *Beatricea,* among the Hydrozoa, but, by a printer's error, *Calapoecia huronensis* and *Tetradium huronense* were dropped from the base of the list of Anthozoa (on page 59 of the publication cited) to the top of the Hydrozoa, where they are altogether out of place.

Another specimen of *Apsidoceras insigne,* originally of about the same size as the type of this species, had a dorso-ventral

[3] Foerste, Aug. F. Geol. Surv. Canada, Memoir 138, 59, 74 (1924).

diameter at the base of the living chamber of 120 mm. Of the upper part of the phragmacone a length of 290 mm. remains. Of the living chamber, a length of 540 mm. is preserved, not including the aperture, which is missing. The living chamber evidently diverged from the preceding volution in a manner similar to the large specimen of *Trochoceras mccharlesi*. About 8 camerae occupy a length equal to the dorso-ventral diameter of the conch. Swampy Island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. Specimen No. 7161, Victoria Memorial Museum.

Another specimen, found at Clark Harbour, Lake Winnipeg, is 660 mm. long, and of this length 275 mm. belongs to the living chamber. In the rate of coiling of the conch, the relative number of its camerae, and in the direction and amount of curvature of the sutures of its septa this specimen resembles the large specimen of *Trochoceras mccharlesi* described above. Its horizon is that of the lower or Dog Head member of the Red River formation.

NARTHECOCERAS Hyatt

Genotype: *Endoceras crassisiphonatum* Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 79, pl. 6, figs. 1–4; pl. 7, fig. 1; *Narthecoceras crassisiphonatum* Hyatt, Amer. Geol., 16, 2 (1895).

Siphuncles of unknown orthoceracones whose segments enlarge but slightly within the camerae. The interior of these siphuncles is occupied by calcareous deposits converging from the walls of the siphuncle toward the center in a radiate manner. These deposits leave elongated funnel-like cavities within the center of the siphuncle, often recognizable as successive stages of growth within those parts of the siphuncle which are almost filled up by these deposits. In older parts of the siphuncle a narrow central tube-like space remains, called the endosiphuncle. Occasionally this endosiphuncle is partitioned transversely at approximately equal intervals. Nothing comparable to endocones is present, and the relationship of these siphuncles still is uncertain. Although no endocones are present in the specimens at hand, the funnel-like cavity along the younger part of the siphuncle, the funnel-like structure of the earlier formed deposits within the

siphuncle, and the narrow, tube-like cavity left at the center of this older part closely simulate the appearance of the deposits *within* the endocones of *Piloceras* and related genera.

The vertical outlines of the segments of the siphuncle in *Narthecoceras* resemble those of *Actinoceras remotiseptum* (Hall), as illustrated by Hall in 1850, and by Clarke in 1897. However, the deposits within the siphuncle of the latter species do not present the elongated funnel-like character seen in *Narthecoceras*.

21. **Narthecoceras crassisiphonatum** (Whiteaves)

Plate XXIV, figs. 1 A, B; Plate XXV, figs. 1, 2

Endoceras crassisiphonatum Whiteaves, Trans. Royal Soc. Canada 9, sec. 4, 79, pl. 6, figs. 1–4; pl. 7, fig. 1 (1892).

Selected type.—Specimen consisting of a fragment of a siphuncle 200 mm. long, not enlarging appreciably in diameter within this length. Three segments occupy a total length of 150 mm. Their diameter increases from 54 mm. at the septal necks to 57 mm. at mid-height within the camerae. Along the upper part of each constriction of the siphuncle there is a faint angularity in the vertical outline of the siphuncle. This angularity extends as a transverse line around the siphuncle and locates the level at which the lower margin of the connecting rings came in contact with the upper part of the septal neck immediately beneath. Immediately below this line the concave curvature of the vertical outline of the siphuncle is slightly accentuated, the transverse line sloping from the ventral toward the dorsal side of the siphuncle at an angle of 20 degrees beneath the horizontal. The siphuncle has been sectioned both dorso-ventrally and transversely. The dorso-ventral vertical section exposes a long funnel-like cavity whose original length was at least 250 mm., and may have equalled 300 mm. This cavity does not appear to be due to an endocone, but is the central space left by calcareous deposits lining the inner walls of the siphuncle. These deposits began at the lower end of the specimen, and gradually grew both upward and inward, leaving a very elongated funnel-like central cavity, the latter now being filled by matrix. This central cavity is nearly circular along the upper part of the specimen, but is irregu-

larly angular at its base. The structure of the calcareous deposit is fibrous, the individual fibers being approximately vertical to the walls of the siphuncle. Viewed along a cross-section transverse to the length of the siphuncle, these fibers appear like rays radiating from a central area. This deposit apparently is actinoceroid in character.

Locality and horizon.—East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. Specimen No. 1866, Victoria Memorial Museum. Original of Whiteaves's figure 4 on plate 6, and figure 1 on plate 7 of the publication cited above. A small orthoceroid is imbedded in the matrix near the lower end of the funnel-like central cavity. Pl. XIV, figs. 1 A, B.

Red River Valley specimen.—The original of Whiteaves's figure 2 on plate 6, cited above, is a specimen 125 mm. long. It shows several stages of the deposition of calcareous material, and a central tube-like cavity, the endosiphuncle, from 2 to 3 mm. wide, at present filled with crystalline calcite. From some unknown locality in the Red River Valley; presumably from the same horizon as the preceding. Specimen No. 1870, Victoria Memorial Museum. Plate XXV, Fig. 1.

Lower Fort Garry specimen.—The original of Whiteaves's figure 3 on plate 6, cited above, is 80 mm. long. Traces of former locations of the central funnel-like cavity are preserved. Its most interesting feature is the closing of the tube-like endosiphuncle, at successive intervals of growth, by small transverse septa, curving concavely downward. These septa vary in distance from 12 to 15 mm. apart. From the same horizon as the preceding. Specimen No. 1867, Victoria Memorial Museum. Plate XXV, Fig. 2.

The original of Whiteaves's figure 1, on plate 6, of the publication cited above, was missing even before the first catalogue of the specimens in Victoria Memorial Museum was prepared.

22. **Narthecoceras simpsoni** (Billings)

Plate XXV, fig. 5

Orthoceras Simpsoni Billings, in Hind, Narrative of Canadian Red River Explor. Exped. of 1857 and of Assiniboine and Saskatchewan Exped. of 1858, 2, 287, fig. (1860).

Orthoceras Simpsoni Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 80, pl. 7, figs. 2, 3, 3a; pl. 8, fig. 1 (1892).

Gull Harbour specimen.—Specimen 100 mm. long, two segments occupying a total length of 74 mm. The diameter of these segments increases from 25 mm. at the septal necks to 27.5 at mid-height within the camerae. Hence, this diameter equals about three-fourths of the length of the camerae. The transverse line along which the lower margin of the connecting rings came in contact with the septal funnel immediately beneath slopes downward at an angle of 15 degrees with the horizontal from the ventral toward the dorsal side of the siphuncle. The interior of the siphuncle is filled by a calcareous deposit consisting of fibers which are vertical to the walls of the siphuncle. The chief difference of *Narthecoceras simpsoni*, as here defined, from *Narthecoceras crassisiphonatum* consists in the relatively greater length of the segments of the siphuncle compared with their width.

Locality and horizon.—Gull Harbour, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. Specimen No. 6820, Victoria Memorial Museum.

Black Island specimen.—Specimen 225 mm. long, enlarging from a diameter of 15.5 mm. to 20.5 mm. in a length of 200 mm., indicating an apical angle of about 1.5 degrees. Six segments occupy a length of 175 mm., each of the upper two segments being 30 mm. long. From Swampy harbour, Black Island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation.

Whiteaves listed this species also from Cat Head; Commissioner Island, 7 miles east of Cat Head; Swampy island, 10 miles northeast of Cat Head; Snake island; and Dog Head, 2 or 3 miles east of Snake island. Dowling cites it from both the Cat Head and Dog Head members of the Red River formation.

Remarks.—None of the specimens figured either by Billings or by Whiteaves have turned up since the collections of the Victoria Memorial Museum were moved from the Sussex Street building to the present location of the museum. Under these circumstances, the Gull Harbour specimen, here figured, has been selected as a topotype. It comes from the same general

area, and presumably from the same horizon, as the type of the species.

CALHOUNOCERAS Troedsson

Genotype: *Calhounoceras candelabrum* Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, 1, Cephalopods, in Jubilaeumsekspeditionen Nord om Grønland 1920–23, 77, pl. 45, fig. 5; pl. 46 (1926).

"Siphuncle large, annulated, with broad constrictions, outside of the centre, probably marginal, filled with calcite which is arranged in radiating vertical lamellae. Wall of siphuncular cavity with transversal annulations, corresponding to those of the siphuncle, and strong longitudinal furrows and ridges." (Troedsson)

Calhounoceras differs from *Narthecoceras* in the arrangement of the calcereous deposits within the siphuncle in vertical plates instead of horizontal fibers converging from the walls of the siphuncle toward its center.

23. **Calhounoceras** cf. **candelabrum** Troedsson

Plate XXV, fig. 4

Calhounoceras candelabrum Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, Jubilaeumsekspeditionen Nord om Grønland, 1920–23, Nr. 1, I. Cephalopods, 77, pl. 45, fig. 5; pl. 46, figs. 1–4 (1928).

Specimen consisting of a fragment of a siphuncle 95 mm. long, with a lateral diameter of 36 mm. Strongly annulated, the annulations being regarded as connecting rings and the intermediate grooves as septal necks. The crests of 4 annulations occur in a length of 68 mm. The annulations are about 13 mm. wide and rise about 3 mm. above the deepest part of the intermediate grooves, the width of the latter being 11 mm. The crests are so evenly rounded that in the short length of the siphuncle preserved it is impossible to determine which side of these annulations formed their upper part. The annulations slope downward in a dorsad direction at an angle of 10 degrees with the horizontal.

Locality and horizon.—South end of Snake island, Lake Winni-

peg; in the lower or Dog Head member of the Red River formation. No. 7140, Victoria Memorial Museum.

It is possible that the specimen from Black Bear island, numbered 6794, belongs to the same species. It enlarges from a lateral diameter of 42 mm. to 48 mm. in a length of 130 mm., the crests of 6 annulations occurring in this length. These annulations are similar in prominence and obliquity to those of the preceding specimen, but neither specimen reveals enough of the structure of the siphuncle to make its generic identification certain

ACTINOCERAS Bronn

Genotype: *Actinoceras bigsbyi* Bronn, Lethaea Geognostica, 1, 98, pl. 1, fig. 8 (1837); Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 31, pl. 1, figs. 1, 2 (1924).

Actinoceroid orthocones in which the siphuncles usually are large, compared with the diameter of the conch, and in which the segments of the siphuncle are low, broad, and nummuloidal, while the intervening septal necks are relatively long. The interior of these siphuncles is more or less filled by calcareous deposits which begin as deposits enveloping the inner surface of the septal necks and then continue in growth until only an irregular tube-like space along the central part of the siphuncle remains free from deposition during the life of the animal, though usually occupied by matrix after death. This type of calcareous deposits is characteristic not only of the genus *Actinoceras* but of all the related genera usually grouped under the term *actinoceroids*. In the genotype, *Actinoceras bigsbyi*, the ventral wall of the conch is flattened only slightly; its siphuncle is circular in cross-section, and is free from contact with the ventral wall of the conch, though only slightly separated from the same. No sharply preserved apical ends of the conchs of *Actinoceras* are known, but those found so far suggest that these apical ends were rounded, rather than obliquely funnel-shaped as in typical *Kochoceras*. Moreover, the lowest segment of the siphuncle preserved differed less conspicuously from the immediately overlying segments, being only slightly taller, and evidently smaller in diameter. *Kochoceras* evidently is a derivative of *Actinoceras*, with a conspicuously

ventral side, and with the siphuncle strongly depressed, and in contact with the ventral wall of the conch. The lowest segment preserved presents a funnel like form, obliquely directed, with its basal termination nearer the ventral side of the conch.

24. **Actinoceras bigsbyi** Bronn

Orthocerae —— Bigsby; Trans. Geol. Soc. London, 1, 198, pl. 25, figs. 1, 2, 3, (1824).

Actinoceras Bigsbyi Bronn, Leth. Geog., 1, 98, pl. 1, fig. 8, (1837); also Foord, Cat. Ceph. British Museum, 1, 164, fig. 20, (1888). Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 31, pl. 1, figs. 1, 2 (1924).

The two parts of Bigsby's figure 1, cited above, form a single specimen 140 mm. long. This specimen is numbered 33448 in the British Museum of Natural History. At the break indicated in the figure its lateral diameter is 37 mm. and its dorso-ventral one is about 29 mm. The cross-section appears to be transversely elliptical with its ventral part a little less convex. The siphuncle here has a lateral diameter of 24 mm. and a dorso-ventral one of 20 mm. Its ventral margin is near contact with the ventral wall of the conch. Where the conch is 40 mm. wide, 6 camerae occur in a length of 41 mm.

The original of Bigsby's figure 2 is figured inverted. It is numbered C.2664 in the British Museum of Natural History. The rate of enlargement of the conch is uncertain, but it appears to increase from 37 mm. to 50 mm. within a length of 80 mm. The part exposed probably is the ventral side. Of the filling of the interior of the siphuncle that part corresponding to the 7 annulations of the siphuncle beneath the break is missing. At the larger end of this missing part the lateral diameter of the conch is 51 mm. and that of the siphuncle is 29 mm. On another specimen on the same slab as the original of Bigsby's figure 2 the lateral diameter of the conch enlarges from 35 mm. to 44 mm. within a length of 75 mm.

In another specimen, partially figured by Foord (fig. 20 cited above), the lateral diameter of the conch enlarges from 32.5 mm. to 43 mm. within a length of 50 mm. This is the best of the

series of measurements for determining the rate of enlargement of the conch. The specimen exposes its ventral side. Where the lateral diameter of the conch is 43 mm., that of the siphuncle is 23 mm., and the distance of this siphuncle from the dorsal wall of the conch is 11 mm.

The original of Bigsby's figure 3 cited above exposes the ventral side of a conch. It is numbered C.2668 in the British Museum of Natural History. The lateral diameter at the top of the specimen is 55 mm. The ventral side of the conch evidently was distinctly flatter than its dorsal side. The more expanded part of the annulations of the siphuncle here is 1 mm. from the ventral wall of the conch. At a point 55 mm. beneath the top of the specimen the lateral diameter of the siphuncle is 25 mm. Along the upper part of the specimen 8 camerae occur within a length of 55 mm., which there also is the lateral diameter of the conch at the top of the series of camerae counted. The sutures of the septa curve downward ventrally a distance of about 4 mm. Dorsally these sutures either are horizontal or rise slightly. A larger specimen on the same slab is 70 mm. in diameter laterally. Its siphuncle here is 25 mm. in diameter at the septa, probably equalling 29 or 30 mm. at mid-height of the annulations. The largest specimen in this block has a lateral diameter of at least 85 mm., the corresponding diameter of the siphuncle being 20 mm. at the septa and probably 25 mm. at mid-height of the annulations. It is possible that the siphuncle may become relatively smaller toward the top of the conch.

Locality and horizon.—Thessalon island, in Lake Huron. The conchs occur in light brown dolomitic rock, similar lithologically to that referred to the Beloit formation. According to Bigsby, the specimens of this species were common. (Bigsby, loc. cit., pp. 195, 198, 204). In my own visit to this island I saw only its northern part and failed to find any rock similar to that containing the types of this species.

24A. **Actinoceras** cf. **bigsbyi** Bronn

Plate XXVI, fig. 1

Orthocerae —— *Bigsby*, Trans. Geol. Soc. London, 1, 198, pl. 25, figs. 1–3 (1824).

Actinoceras Bigsbyi Bronn, Leth. Geog., 1, 98, pl. 1, fig. 8 (1837); Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, pl. 1, figs. 1 A, B; 2 (1924).

Specimen 210 mm. long, enlarging laterally from a diameter of 64 mm. at its base to 88 mm. at a point 170 mm. farther up, the apical angle being about 8 or 10 degrees. The ventral side is distinctly flattened, but the remainder of the cross-section probably was approximately semicircular. The number of camerae in a length equal to the lateral diameter of the conch is about 8. The sutures of the septa curve downward about the height of one camera along the ventral side of the conch; dorsally they probably are nearly directly transverse. The siphuncle is located 3 or 4 mm. from the ventral wall of the conch. Its diameter is estimated at nearly 30 mm. where the lateral diameter of the conch is 76 mm. The vertical outlines of the siphuncle are not distinctly preserved, so that it can not be determined whether the septal necks and connecting rings have the same structure as in typical *Actinoceras bigsbyi*, but that part of the deposit within the interior of the siphuncle which remains resembles that shown by the types of that species.

Locality and horizon.—Clark's Point, Lake Winnipeg; Manitoba; in the lower or Dog Head member of the Red River formation. Collected by D. B. Dowling in 1891. No. 5598, Victoria Memorial Museum.

Remarks.—This specimen is of interest on account of its resemblance to fig. 3 on plate 25 accompanying the original article by Bigsby, cited above. The various specimens there figured are cited as coming from Thessalon island, Lake Huron, but the writer failed to find any rock on this island which resembled lithologically that enclosing the types of *Actinoceras bigsbyi*. Hence both the point of origin and the stratigraphical position of this species remain in doubt. It usually is assumed that its horizon is Black River, and the species is cited from New York, Ontario, Kentucky, Tennessee, Minnesota, Manitoba, and Arctic America, but these identifications probably need revision. In the mean time, the Manitoba specimen here described at least bears some resemblance to figures 2 and 3 among those figured

by Bigsby, and used by Bronn in establishing his genus and species *Actinoceras bigsbyi*.

KOCHOCERAS Troedsson

Genotype: *Kochoceras cuneiforme* Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, Jubilaeums-ekspeditionen Nord om Grønland, 68, pls. 37, 38, 39, 40, 44 (1926).

Conch differing from *Actinoceras* chiefly in the distinct flattening of its ventral side. The connecting rings of its siphuncle are in broad contact with this side. The siphuncle as a whole is depressed dorso-ventrally, this depression increasing toward the upper part of the specimens at hand. The lowest part of these specimens usually begins with a form resembling the exterior of a funnel. This funnel slopes obliquely, so that its lower end is ventrad of the center of the conch. On the dorsal side of this lower end there is an opening which represents the lower end of the endosiphuncular passage extending along the vertical axis of the siphuncle. This basal structure of those specimens of *Kochoceras* so far found can not represent the initial stage of the conch, but of the latter nothing is known.

Nothing is known of the structure of any corresponding stage of development in typical *Actinoceras*.

25. **Kochoceras tyrrelli** Sp. nov.

Plate XXVII, figs. 3A, B; Plate XXVIII, fig. 1; Plate XXX, figs. 1, 2

Antinoceras Bigsbyi (?) Foord, Cat. Foss. Ceph. Brit. Mus., 1, 165, figs. 23, 22–2 (1888).

Actinoceras Bigsbyi Whiteaves, Trans. Royal Soc. Canada, 9, 84, pl. 10, fig. 2 (1898).

Specimen 140 mm. long, enlarging at an apical angle of 15 degrees from a lateral diameter of about 43 mm. at its base to 61 mm. at a point 75 mm. farther up. The ventral side is gently convex toward the base but distinctly flattened farther up. At its base the dorso-ventral diameter is 35 mm. Farther up, the

dorsal side of the conch is weathered away. The septum at the base of the specimen is obliquely funnel-shaped, its lower end being distinctly nearer the ventral side of the conch. The height of this funnel is about 25 mm. The opening at its base is 5 mm. in diameter and its margin is 3 mm. dorsad of the lowest part of this septum. This opening is the lower end of the endosiphuncular passage traversing lengthwise the calcareous deposits filling the interior of the siphuncle. The suture of the basal septum slants faintly downward from the dorsal toward the ventral side of the conch. All of the other sutures curve strongly downward along the ventral side of the conch, but only slightly downward, in the opposite direction, dorsad of the ventro-lateral angles of the conch, producing distinct ventro-lateral saddles. Along the ventro-lateral sides of the conch the camerae are 15 to 16 mm. long. At the base of the specimen the lowest segment of the siphuncle occupies the entire dorso-ventral diameter of the conch, 35 mm., but the overlying segments become successively more depressed until the seventh segment above the basal one has a dorso-ventral diameter of only 16 mm. In a lateral direction the siphuncle probably expands at higher elevations but little beyond its lateral diameter at the base of the specimen. Ventrally the siphuncle is in contact with the ventral wall of the conch along broad lenticular areas equalling 42 mm. in width, where the lateral diameter of the conch is 60 mm. Along that side of the siphuncle which faces the interior of the conch, the septal necks vary from 3 to 5 mm. in length. The annulations produced by the connecting rings here are approximately 9 mm. in length and extend toward the interior of the conch for a distance of 6 or 7 mm. beyond the most remote parts of the septal necks. Along the ventral side of the conch the septa are adnate to the oblique lower face of the connecting rings along their entire length. At the lower 5 septal necks, the upper surface of the immediately underlying connecting rings curves abruptly upward until almost in contact with the overlying septum before curving outward toward the ventral wall of the conch. At the sixth and seventh septal necks from the lower end of the specimen the upper surface of the underlying connecting ring remains about 1 mm. distant

from the septum above, before curving outward toward the ventral wall. The interior of the siphuncle is filled with calcareous deposits, leaving a central opening, the endosiphuncle, with an irregular course at its base, becoming straighter farther up. Along the upper part of the specimen this endosiphuncle is much closer to the dorsal side of the siphuncle. The endosiphuncular opening at the base of the specimen is evidence that this part of the specimen does not represent the initial end of the complete conch, but it is the earliest part of the conch preserved.

Locality and horizon.—Swampy Island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. Specimen No. 7139, Victoria Memorial Museum. Plate XXVII, figs. 3 A, B; plate XXVIII, fig. 1.

Second Swampy Island specimen.—The second specimen from the same locality and horizon as the type of *Kochoceras tyrrelli* has the same rate of enlargement laterally and may belong to the same species, but its ventral side is more strongly flattened, and its camerae are relatively more numerous, their length being only 11 or 12 mm. The specimen is 190 mm. long, and enlarges laterally from a diameter of 43 mm. at its base to 58 mm. at a point 65 mm. farther up. Its internal structure is unknown. Specimen No. 7139b, Victoria Memorial Museum. Plate XXX, figs. 1 A, B.

The specimen illustrated by figure 2 on plate 10, published by Whiteaves as cited above was numbered 2724 in the original catalogue of the collections now preserved in Victoria Memorial Museum, but this specimen has not turned up since the collections were moved from Sussex street.

25A. **Kochoceras** cf. **tyrrelli** Foerste

Plate XXVIII, fig. 2; Plate XXIX, figs. 1 A, B

Actinoceras Bigsbyi Foord, Cat. Foss. Ceph. Brit. Mus., 1, 165, figs. 23, 22(2), (1888).

Specimen 170 mm. long, enlarging in a lateral direction from 41 mm. to 53 mm. within a length of 120 mm. Only the lower part of this specimen was illustrated by Foord. The ventral side is

well preserved, and is strongly flattened. The lowest suture appears to curve upward, but less strongly than in Foord's figure, being about 9 mm. distant from the suture immediately above. All other sutures curve downward ventrally. The amount of this downward curvature increases at later stages of growth, and equals 18 mm. at the top of the specimen. These sutures form strong lateral saddles and curve downward dorsally as much as ventrally at the top of the specimen. The siphuncle is in contact with the ventral wall of the conch for a width of at least 45 mm. at the top of the specimen. Dorsally, the specimen is strongly weathered, but the siphuncle appears to have been more or less depressed also on this side of the conch.

Locality and horizon.—Great Slave Lake; presumably in the equivalent of the Red River formation. British Museum of Natural History. Specimen No. C.2673.

SELKIRKOCERAS Gen. Nov.

Genotype: *Selkirkoceras cuneatum* Foerste, Jour. Sci. Lab. Denison Univ., 24, 29 (1929).

Selkirkoceras differs from *Kochoceras* only in the absence of distinct septal necks separating the adjacent connecting rings of the siphuncle. Instead, both the overlying and the underlying connecting rings are adnate to the inner parts of the intermediate septa for a considerable width surrounding the passage of the siphuncle through the septa. In the latter structure, *Selkirkoceras* resembles *Armenoceras*, just as *Kochoceras* resembles typical *Actinoceras*, the two latter genera differing from the two former by possessing distinct septal necks separating the connecting rings.

26. **Selkirkoceras cuneatum** Sp. nov.

Plate XXXI, figs. 2 A, B

Actinoceras richardsoni Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 83, pl. 9, figs. 3, 3a (1892).

Specimen 96 mm. long, enlarging laterally at an angle of 23.5 degrees from a diameter of 61 mm. near its lower end to 90 mm. at its top, the interval being 70 mm. The corresponding diameter

at the lower end of the specimen is 38 mm. and its former diameter at its top is estimated to have been at least 45 mm., possibly 55 mm., the larger number being suggested by the crushed-in appearance of the dorsal side of the specimen. The lower end of the specimen, for a height of 26 mm., is rounded, especially at its extreme base. The ventral side of this rounded end passes smoothly upward into the ventral side of the remainder of the specimen, but dorsally and laterally there is an angulation between the walls of the rounded end and the dorsal and lateral walls of the main body of the specimen, at the height of 26 mm. above the base of the rounded end mentioned above. This angulation slopes downward in a ventrad direction. Above this angulation the specimen exposes the sutures of four septa, all of which curve slightly downward along the dorsal face of the specimen. Ventrally, the downward curvature of these sutures was considerably greater. The upper half of the ventral side of the specimen has been ground away, exposing the siphuncle. Here the segments of the siphuncle are 10 mm. in height, and diminish in diameter from 37.5 mm. at the lowest segment exposed to 35 mm. at the uppermost one. These segments are in contact with the ventral wall of the conch for a width of 23 mm. The inner margin of the septa at the passage of the siphuncle curves only faintly downward, without producing a distinct neck, the passage of the siphuncle through the uppermost septum exposed being 13 mm. in diameter. This segment is in contact with the lower face of the immediately overlying segment for a width of 9 mm., and with the upper face of the next underlying segment for a width of 7 mm. The interior of the siphuncle once was occupied by calcareous deposits of which traces remain. Along the central part of the siphuncle an irregular narrow tube-like passage was left, the lower end of which is exposed, at the tip of the rounded basal end of the specimen, as an opening 3 or 4 mm. wide.

Locality and horizon.—East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 1852, Victoria Memorial Museum.

27. **Selkirkoceras tyndallense** Sp. nov.

Plate XXXI, figs. 1 A, B, C, D

Specimen consisting of the lower part of a siphuncle, with a structure closely similar to that of typical *Kochoceras*, but differing from the latter in the absence of distinct septal necks, the septa being adnate both to the upper face of the underlying segments of the siphuncle as well as to the lower face of the overlying segments. The specimen is 74 mm. long, and includes in this length five and a half segments differing greatly in size and form. The lowest segment is 29 mm. high, has a lateral diameter of 49 mm., and a dorso-ventral one of 32 mm. Its ventral side is distinctly flattened, its dorsal side is broadly rounded, and its lateral sides are much more narrowly rounded. Its general form, especially when viewed from the dorsal side, is that of a broad funnel, but rounded at its base. The lateral diameter of the succeeding segments equals 40, 34.5, 31.5, 28.5, and 26 mm. The dorso-ventral diameter of these succeeding segments equalled approximately 29, 27, 25, 24, and 23 mm. The 3.5 segments forming the upper half of the specimen have been sectioned vertically in a lateral direction through the center of the siphuncle. Here the septa can be traced inward toward the central part of the siphuncle for distances of 8 or 9 mm. from the vertical projection of the outer margin of the connecting rings. The inner margin of these septa curves moderately downward, but not sufficiently to form septal necks, and both the overlying and underlying connecting rings are in contact with these septa for a radial distance of 7 mm. from the central passage of the siphuncle through the septa.

Locality and horizon.—Tyndall, 32 miles southeast of East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 5653, Victoria Memorial Museum.

Remarks.—This species is characterized by the flattening of its ventral side, and the rapid rate of diminution of its diameter both laterally and dorso-ventrally.

ARMENOCERAS Foerste

Genotype: *Actinoceras hearsti* Parks, Trans. Royal Canadian Inst., 11, 73, pl. 6, fig. 5 (1915); *Armenoceras hearsti* Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 32 (1924); Geol. Surv. Canada, Memoir 145, 73 (1924); Jour. Sci. Lab. Denison Univ., 22, 68, pl. 8, fig. 4; pl. 24, fig. 5 (1927).

Conchs differing from typical *Actinoceras* chiefly in the absence of distinct septal necks, both the overlying and the underlying connecting rings being adnate to the intermediate septa for a considerable width in the area immediately surrounding the passage of the siphuncle through the septa. In those species in which the underlying connecting rings are not adnate to the septa immediately above, they meet the inner margin of these septa at a very acute angle, without a distinct septal neck intervening.

28. **Armenoceras richardsoni** (Stokes)

Plate XXXII, figs. 1A, B

Actinoceras richardsoni Stokes, Trans. Geol. Soc. London, ser. 2, 5, pt. 3, 708, pl. 59; figs. 2, 3 (1840); Whiteaves. Trans. Royal Soc. Canada, 9, sec. 4, 83, pl. 9, figs. 2, 2a (1892).

Armenoceras richardsoni Foerste, Jour. Sci. Lab., Denison Univ., 23, 75, pl. 21, fig. 1 (1928).

Specimen 127 mm. long, its lateral diameter increasing from 65 mm. at its base to 83 mm. at its top, 95 mm. farther up, the apical angle being 11 degrees. The cross-section apparently is circular, but only the ventral half of the specimen remains, the dorsal half having weathered away. Eight camerae occupy a length equal to the diameter of the conch. The siphuncle is 36 mm. in diameter at the base of the specimen and 49 mm. at its top, the ratio of its diameter to that of the conch varying between 0.52 and 0.56 within the length of the specimen. The distance between the siphuncle and the ventral side of the conch varies from 5 or 6 mm. at the lower end of the specimen to approximately 8 mm. at its top. The concavity of the septa varies from 16 mm. at the base of the specimen to 24 mm. at its top. A verti-

cal section has been cut in a lateral direction through the center of the siphuncle. Where the lateral diameter of the siphuncle is 47.5 mm., that of the passage of the siphuncle through the septum is 28 mm. Between the connecting rings this septum is more nearly horizontal and its inner margin curves slightly downward, but does not form a septal neck. This inner margin extends about 9 mm. inward from the vertical projection of the outer margin of the septal rings. These rings are in contact both with the septa above and below for a radial width of 5 mm. The interior of the siphuncle is filled with typical actinoceroid deposits of calcareous material, leaving the usual central endosiphuncular passage. The thickness of the shell varies from 1.5 to almost 2 mm. The surface of the shell is marked by horizontal bands of growth, usually varying in distance from each other 3 or 4 mm., but sometimes spaced considerably farther. Original of Whiteaves's figures 2, 2a, cited above.

Locality and horizon.—Lower Fort Garry, Manitoba; in the upper or Selkirk member of the Red River formation. No. 1854, Victoria Memorial Museum.

Remarks.—This species was described "from Lake Winnipeg, in yellowish-white limestone much resembling that from Igloolik." According to Whiteaves it probably was collected from the first and second limestone points on the west side of Lake Winnipeg, north of the Saskatchewan where it was collected by Sir John Richardson on Franklin's first expedition in 1814 and subsequently by Captain Back in 1832. It is not absolutely certain that the species so common at Lower Fort Garry and East Selkirk is identical with that described by Stokes, but it is at least closely similar.

The type described by Stokes, as cited above, appears to enlarge more slowly, the septa are slightly more numerous in a length equal to the diameter of the conch (equalling 9 instead of 8), and the diameter of the siphuncle compared with that of the conch is less, equalling only 0.46 instead of 0.52 to 0.56. However, the Lower Fort Garry specimen here described is much better preserved than the original type, and the differences do not seem sufficient to warrant its separation as a distinct species.

Another specimen from lower Fort Garry, numbered 1853, is of interest because the surface of its shell is crossed by 9 transverse bands in a length of 30 mm. where the diameter of the conch is 65 mm. There are only 7 camerae in a length equal to the diameter of the conch. A third specimen from the same locality has camerae varying in number from 8 at the lower end of the specimen, where its diameter is 48 mm., to 9 at its upper end, where its diameter is 58 mm.

In a specimen from East Selkirk, numbered 1852, the transverse banding is very distinct, the number of bands in a length of 20 mm. varying from 15 at the lower end of the specimen to 9 or 10 at its upper end, the corresponding diameters of the conch being 60 and 70 mm.

In a specimen from St. Andrews the surface of the shell is transversely banded in a manner similar to *Geisonoceras*, but the banding is both inconspicuous and irregular. No banding whatever is shown by the specimen from well 12, of the Winnipeg City wells.

The specimen represented by figure 1 on plate 9 published by Whiteaves, as cited above, is missing.

29. **Armenoceras sp.** (Stony Mountain)

Specimen consisting of a fragment of a siphuncle 230 mm. long, enlarging from a lateral diameter of 68 mm. at its base to 73.5 mm. at a point 195 mm. farther up. Orginally its cross-section probably was circular, but at present the ventral side of the siphuncle is moderately weathered away. There is a slight downward slope of the segments of the siphuncle in a dorsad direction, the amount of this slope equalling only 2 or 3 degrees. The number of segments in a length equal to the diameter of the siphuncle varies from three and two-thirds at the lower end of the specimen to three and a fourth at its upper end. It is not known how far inward the septa extend beyond the line at which adjacent segments of the siphuncle appear to come in contact with each other, but the structure is assumed to be as in *Armenoceras*. The interior of the siphuncle is filled with calcareous deposits showing more or less radiating structure as in numerous

actinoceroids, but at the center of the siphuncle a large circular cavity remains which is 26 mm. in diameter at the base of the specimen and about 30 mm. in diameter at a point 140 mm. farther up.

Locality and horizon.—Stony Mountain, Manitoba; in the Stony Mountain member of the Richmond group. Victoria Memorial Museum.

Remarks.—Contrasted with *Armenoceras richardsoni*, the segments of the siphuncle are relatively a little taller, the number of segments in *Armenoceras richardsoni* being 4.5 in a length equal to the diameter of the conch.

A second specimen from the same locality and horizon is 300 mm. long. One fragment of the specimen varies in diameter from 43 mm. to 41 mm. in a length of 85 mm. The general structure of the specimen is similar to that of *Armenoceras*. The interior of the siphuncle is filled with radiating calcareous material which along that part of the specimen regarded as its lower half occupies all except the central part of the siphuncle, where the endosiphuncle is about 4 mm. wide. Along the other half of the specimen this central tube-like space enlarges to a diameter of 19 mm. Theoretically the latter should be the upper half of the specimen, but the diameter of the specimen diminishes in this direction, at least along the lower half of the specimen. There are almost 4 segments within a length equal to the diameter of the siphuncle where the latter is 43.5 mm.

30. **Armenoceras** cf. **allumettense** (Billings)

Plate XXXIII, fig. 1 A, B

Actinoceras Allumettense Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, 210 (1897); Lower Fort Garry specimen.

Specimen 153 mm. long, enlarging from a lateral diameter of 20 mm. at its base to 38 mm. at a point 140 mm. farther up, the apical angle being 7 degrees. The cross-section, apparently, was circular. The number of camerae in a length equal to the diameter of the conch equals 5 at the lower end of the specimen, increasing to 5.5 along its middle and upper parts. Where the diameter

of the conch is 32 mm., the concavity of the septa is 5 mm., the length of the camerae is 6 mm., and the maximum diameter of the segments of the siphuncle is 11.5 mm. The inner margin of the septa, at the passage of the siphuncle through the septa, curves faintly downward. The connecting ring beneath each septum meets this inner margin at an acute angle; a similar acute angle is shown where the immediately overlying connecting ring meets the same septum; this structure is characteristic of *Armenoceras*. The inner margin of the septa and the inner walls of the connecting rings are covered with calcareous deposits, which at the septa extend entirely across the siphuncle, thus closing the passage from segment to segment throughout the siphuncle. These deposits are interpreted provisionally as of an actinoceroid character. The center of the siphuncle is estimated at 9.5 mm. from the ventral wall of the conch where the diameter of the latter is 29.5 mm. and where the diameter of the segments of the siphuncle is 9 mm. This places that side of the siphuncle facing the interior of the conch at the center of the conch. The sutures of the septa apparently slope slightly downward in a ventrad direction, and the surface of the shell apparently was smooth.

Locality and horizon.—St. Andrews, Lower Fort Garry, Manitoba; in the upper or Selkirk member of the Red River formation. No. 1833, Victoria Memorial Museum.

Remarks.—This Lower Fort Garry specimen evidently is closely related to *Armenoceras allumettense* (Billings), and it will require comparison with typical specimens of the latter to discover differences in structure, if any exist.

31. **Armenoceras** sp. (Great Slave Lake)

Plate XXV, fig. 3

Endoceras sp. Foerste, Geol. Surv. Canada, Bull. 44, 66, pl. 14. figs. 1 A, B (1926); Jour. Sci. Lab. Denison Univ., 22, 27, pl. 1, figs. 2 A, B (1927).

A vertical section through the lower end of this specimen in a dorso-ventral direction through the center of the siphuncle shows

that this siphuncle has an actinoceroid structure. The vertical section is 65 mm. long, and in this length the conch enlarges from 45 mm. to 50 mm. in diameter. The corresponding diameters for the siphuncle are 12 mm. and 16 mm. The ratio between the diameter of the siphuncle and that of the conch appears to be between 0.25 and 0.32 at the bottom and top of the section respectively. The distance of the siphuncle from the ventral wall of the conch is somewhere between 3 and 4 mm. Along that side of the siphuncle which faces the interior of the conch, the convex vertical outlines of the connecting rings are preserved distinctly, but the septa are not preserved, and therefore the character of the contact between the connecting rings and the septa can not be determined. However, the relative height of these connecting rings, compared with the diameter of the siphuncle suggests a structure similar to that of *Armenoceras*. Along the ventral side of the siphuncle, only the contrast between the color of the matrix filling the camerae and that of the matrix filling the siphuncle makes it possible to determine approximately the location of the ventral wall of the latter. Judging from the inclination of the matrix occupying that part of the camerae which extends between the ventral wall of the siphuncle and the adjacent part of the ventral wall of the conch, the septa here sloped strongly downward toward the interior of the conch.

Locality and horizon.—Great Slave Lake, west side of North Arm, 10 miles northwest of Red Rock Point. Collected by George S. Hume. No. 5647, Victoria Memorial Museum.

Remarks.—Red Rock Point is about 30 miles north of the southern end of the western shore of the North Arm of Great Slave Lake. Ten miles northwest of Red Rock Point, in the bay between Spruce and High Points, there is an exposure containing a *Receptaculites* similar to *Receptaculites oweni*, and farther north rocks of about the same age contain *Halysites gracilis* and *Paleofavosites asper*. Associated with the *Receptaculites* were 3 cephalopods, of which one is the specimen here referred to the genus *Armenoceras;* the second was described as *Orthoceras* (?) *slavense;* and the third was referred provisionally to *Plectoceras*. The first three species, if associated, suggest that the horizon belongs to

some part of the Red River formation. The presence of this formation in the Great Slave Lake area is suggested also by the specimen of *Kochoceras* figured by Foord from this area and here identified with *Kochoceras tyrrelli*. No additional information has been secured regarding the specimens described as *Orthoceras* (?) *slavense* and *Plectoceras* sp.

ORMOCERAS Stokes

Genotype: *Ormoceras bayfieldi* Stokes, Trans. Geol. Soc. London, 2nd ser., 5, 709, pl. 40, fig. 1 (1840); Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 63, pl. 3, figs. 1 A, B; text fig. 1 (1924).

Conchs differing from *Actinoceras* in their much narrower and less nummuloid segments of the siphuncle, and in their much shorter septal necks. In *Armenoceras* the septal necks are entirely lacking, and the segments of the siphuncle are distinctly and broadly nummuloidal.

32. **Ormoceras lambei** Sp. nov.

Plate XXXIII, fig. 2; Plate XVII, fig. 3; Plate XXVI, fig. 5

Actinoceras Allumettense Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, 210 (1897); Black Bear island specimen.

Specimen 188 mm. long, enlarging laterally from a diameter of 43 mm. at a point 45 mm. above its base to 56 mm. at a point 85 mm. farther up, the apical angle being estimated at 9 degrees. The ventral side of the conch has been weathered away, so as to expose the septa and the siphuncle. The siphuncle evidently was located distinctly ventrad of the center of the conch, probably sufficiently to place the entire siphuncle on the ventral side of this center. Fully two thirds of the dorso-ventral diameter of the siphuncle has weathered away, so that only that third remains which faces the interior of the conch. It is estimated that 5 camerae occupy a length equal to the lateral diameter of the conch. Where this lateral diameter is 43 mm., the concavity of the septa equals 9 mm.; the maximum diameter of the siphuncle here is estimated at 13 mm., and the height of its camerae varies from 9 to 10 mm. From these dimensions of the siphuncle and

camerae it is estimated that the form of the segments of the siphuncle was globular, but slightly depressed vertically at the contacts between successive segments. The septal necks are short, usually 0.7 mm. or less in length, with their lower margins flaring widely where they connect with the connecting rings. The interior of the siphuncle is occupied by a light yellowish brown matrix showing no trace of actinoceroid structure.

Locality and horizon.—Black Bear island, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 7141, Victoria Memorial Museum. Plate XXXIII, fig. 2.

Second specimen.—A second specimen, numbered 6837, in a whitish calcareous matrix, is from Tyndall, in Manitoba, and was found in the upper or Selkirk member of the Red River formation. It is badly crushed laterally, but its siphuncle is well preserved. This siphuncle is excentric in location, between the center and the ventral wall, no part extending as far as the actual center of the conch. Four segments of the siphuncle occupy a total length of 47 mm., their diameter equalling 14.5 mm. Their general form is spherical, except where successive segments are in actual contact with each other. The concavity of the septa is considerable, and the septal necks vary in length from about half a millimeter to a little longer or shorter. The upper camerae retain distinct traces of deposits enveloping the inner side of the septal necks as in typical actinoceroids. Plate XVII, fig. 3; plate XXVI, fig. 5.

Remarks.—Compared with typical *Orthoceras allumettense* (Billings),[4] from the Black River formation at the Paquette rapids, at the eastern end of Allumette island, 70 miles northwest of Ottawa, Ontario, Canada, the segments of the siphuncle are much more nearly spherical, rather than flattened nummuloidal in form, and the camerae are relatively taller.

PARACTINOCERAS Hyatt

Genotype: *Sactoceras canadense* Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 85, pl. 10, figs. 1 a–c (1892); *Paractinoceras*

[4] Billings, E. Geol. Surv. Canada, Rept. Progress for 1853–56, 331 (1857).

canadense Hyatt, Zittel-Eastman Textbook of Paleontology, 528 (1900).

Conch narrow and relatively slender, the long living chamber tapering toward the aperture; distinctly compressed dorso-ventrally, at least in its present condition. Sutures of the septa curving downward along the ventral side of the conch. Siphuncle located near the ventral side of the conch but not in direct contact with the latter. The septal necks are long, as in typical *Actinoceras*, however, the intermediate connecting rings are not broad and nummuloidal, but much smaller in diameter than in typical specimens of that genus. These connecting rings become still smaller in diameter on approaching the upper part of the phragmacone, though not as small as suggested by the vertical section prepared by Whiteaves, which is diagonal to a strictly vertical plane placed in a lateral direction.

The most striking feature shown by the type of this species, which is the only specimen found so far, is the complete absence of calcareous deposits within the siphuncle. In fact, in the camerae 7 to 11 from the top of the specimen only a few short traces of the connecting rings are left. This is entirely unexpected among conchs regarded as related to the actinoceroids in structure. On the other hand, the rounded apical termination of the conch (as figured and described by Whiteaves), completely filled by the lowest segment of the siphuncle, suggests a structure similar to that of *Kochoceras* and *Selkirkoceras*, the actinoceroid structure of which is unquestioned. Unfortunately the apical third of the phragmacone of this type no longer can be found, though clearly figured and described by Whiteaves.

33. **Paractinoceras canadense** (Whiteaves)

Plate XIV, fig. 2; Plate XXVI, figs. 3 A, B

Sactoceras Canadense Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 85, pl. 10, figs. 1 a–c (1892).

Paractinoceras Canadense Hyatt, Zittel-Eastman Textbook Pal., 528 (1900).

Specimen 230 mm. long; of this length between 80 and 84 mm.

belongs to the living chamber. Its maximum lateral diameter, at the base of the second camera beneath the living chamber, is 35.5 mm. From this point it narrows to 29 mm. at the aperture, about 90 mm. farther up, and to 22.5 mm. in a similar length in an apicad direction. In its present condition the conch is not only flattened dorso-ventrally but also weathered away dorsally. With the dorsal part restored it is estimated that the dorso-ventral diameter was 28 mm. where the lateral diameter is 35.5 mm. The original dorso-ventral diameter can not be determined, but it probably was less than the lateral one, though greater than at present. The number of camerae in a length equal to the lateral diameter varies from 2 at the lower end of the specimen to 4 at its largest diameter, but the uppermost camera is distinctly shorter than the rest. The sutures of the septa at the top of the phragmacone curve downward about 5 mm. ventrally, their downward curvature being less along its lateral sides. Where the lateral diameter of the conch is 35.5 mm., the septa curve downward 6 mm.; the maximum diameter of the siphuncle within the camerae here is 4.5 mm., and the center of this siphuncle is 3.75 mm. from the ventral wall of the conch, its present dorso-ventral diameter being estimated at 28 mm. The septal necks vary from 2 to 2.5 mm. in length along the greater part of the phragmacone, with the greater of these lengths predominating. The connecting rings occupy almost the entire width of the conch at the base of the phragmacone, but a much smaller part toward its top, the segments of the siphuncle varying from depressed nummuloidal near the base of the specimen to nearly spherical at the seventh and eighth segment from the top, finally becoming elongated in a vertical elliptical manner along the upper part of the phragmacone. The base of the siphuncle is convexly rounded in a manner suggesting the apical end of the siphuncle in specimens included by Troedsson in his genus *Kochoceras*. No trace of markings on the surface of the shell remains.

Locality and horizon.—Swampy or Berens island, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 1839, Victoria Memorial Museum. The

lower part of this specimen, including 6 segments of the siphuncle, is missing. However, the presence of glue at the bottom of that part of the specimen remaining indicates that this part once was present, and, no doubt, was used by Whiteaves in the preparation of the lower part of fig. 1a on his plate 10, cited above.

HURONIA Stokes

Genotype: *Huronia bigsbyi* Stokes, Trans. Geol. Soc. London, 2nd ser., 1, explanation of pl. 28 (1824); Proc. Geol. Soc. London, 2, 689 (1838); also Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 44, pl. 4, fig. 1; pl. 11, fig. 1 (1924).

Conchs with large siphuncles, the segments of which tend to take the form of short inverted pestles, the annulations forming the upper third or two fifths of the length of the segments. In the more typical species the lateral outlines of the lower and middle parts of these segments tend to be approximately vertical, but in other species commonly referred to the same genus these segments contract conspicuously toward their lower ends so that these outlines become oblique. The inner margins of the septa curve downward, but without forming distinct septal necks. Both the segments above and those below each septum are adnate to the latter for some distance around the passage of the more central part of the siphuncle through the septa. The annulations of the siphuncle are directly below the septa. The septa are adnate not only to the basal part of the segments of the siphuncle, but also to the lower and middle of the lateral parts of these segments, becoming free from the latter where the vertical outlines of the annulations begin to rise strongly.

34. **Huronia occidentalis** Foerste

Huronia occidentale Foerste, Jour. Sci. Lab. Denison Univ., 23, 97, pl. 10, figs. 1 A, B; 2.

Locality and horizon.—Mocassin Mountain, in Big Horn range of Wyoming; specimen in U. S. National Museum. Also from mouth of Red River in southern Manitoba; in the upper or Selkirk member of the Red River formation. Specimen no. 4762 in U. S. National Museum.

LAMBEOCERAS Foerste

Genotype: *Gonioceras lambii* Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 86, pl. 11, figs. 1 a, b (1892); *Lambeoceras lambi* Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 45 (1917).

Conchs closely related to *Gonioceras*, but differing in their cross-section and in the course of the sutures of the septa. The conch is strongly compressed dorso-ventrally, both the dorsal and ventral sides are convex, the lateral parts of the cross-section forming an acute angle, but the latter is not thin and sharp as in that genus. The sutures of the septa curve strongly downward both dorsally and ventrally, curving moderately outward for a short distance, in a slightly sigmoid manner, on approaching the lateral outlines of the conch. But these sutures do not form strongly elevated and conspicuous saddles along the lateral fourths of the dorsal and ventral faces of the conch as in typical *Gonioceras*. The siphuncle is actinoceroid in appearance, but contains no calcareous deposits, though such deposits appear to occur in species described by Gustaf Troedsson from the Ordovician of Northwest Greenland.

35. **Lambeoceras lambii** (Whiteaves)

Plate XXXIV, fig. 1

Gonioceras lambii Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 86, pl. 11, figs. 1 a–b (1892).

Specimen 265 mm. long, enlarging laterally from a diameter of 124 mm. to 172 mm. in a length of 205 mm., indicating a lateral apical angle of 13 degrees. In a dorso-ventral direction the diameter increases from 42 mm. at its base to 61 mm. at a point 160 mm. farther up, indicating an apical angle in this direction of 7 degrees. The conch is convex both dorsally and ventrally, the dorsal convexity equalling 35 mm. and the ventral one 22.5 mm., the former having a radius of 100 mm. and the latter of 165 mm. The lateral sides are bluntly angular. Five camerae occupy a total length of 55 mm. when measured at the base of the specimen along the median line of the conch. At mid-length of the specimen they occupy a total length of 53 mm. At one-

fifth of the length of the specimen from its upper end they occupy a total length of 38 mm., increasing to 43 mm. at its very top. From this it is evident that the camerae shorten toward the top of the specimen, but in a moderately irregular manner. The downward curvature of the sutures of the septa on the dorsal side of the conch equals 33 mm. at the base of the specimen and 36 mm. at mid-length, the concavity of the dorsal lobes becoming relatively less, compared with the lateral diameter of the conch, at later stages of growth. Along the ventral side of the conch the corresponding lobes are slightly deeper, since the septa slope downward from the dorsal toward the ventral side of the conch at an angle of 5 or 6 degrees with the horizontal. Near the lateral margins of the conch the sutures of the septa curve slightly outward, reversing their curvature in a weakly sigmoid manner. In a dorso-ventral direction the septa present no concave curvature. At mid-length of the specimen the ventral side of the siphuncle appears 4 mm. distant from the ventral wall of the conch. At this point the lateral diameter of the siphuncle is 22 mm., increasing to 25 mm. at the top of the specimen. At the latter point, the dorso-ventral diameter of the conch is estimated at 21 or 22 mm. The upper two-fifths of the length of the ventral face has been sectioned vertically in a lateral direction through the center of the siphuncle. At the top of the specimen the septa come in contact with the lower side of the segments of the siphuncle at a point 8 or 9 mm. from the center of the siphuncle; from here the septal necks curve downward in a funnel-shaped manner for a vertical distance of 4 mm. to a point 4 mm. from the center of the siphuncle, leaving a central passage for the siphuncle 8 mm. in diameter. The upper face of the connecting rings curves upward in a direction parallel to the septal necks, and in some cases is in contact with the latter, and in other cases is separated from the latter by a distance equalling 1.5 or 1.7 mm. About one-fifth of the length of the specimen from its top, where the camerae are shorter, the connecting rings are in contact with the lower surface of the septal necks. Above and below this point they are distinctly free from contact. The shell is about 1 mm. thick; no surface ornamentation is preserved.

Locality and horizon.—East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. No. 1872, Victoria Memorial Museum.

36. **Lambeoceras** cf. **princeps** Troedsson

Cf. *Lambeoceras princeps* Troedsson, Jubilaeumsekspeditionen Nord om Grønland 1920–23, Nr. 1, I, Cephalopods, 46, pl. 19, fig. 2; pl. 20, pl. 21; pl. 25, figs. 4, 5 (1926).

Specimen 110 mm. long, enlarging from a lateral diameter of 74 mm. at its base to 97 mm. at a point 77 mm. farther up, indicating a lateral apical angle of 17 degrees. At the upper diameter the ventral lobes of the sutures curve downward 33 mm., and the lateral ends of these sutures curve slightly outward, as in the figures of *Lambeoceras princeps* presented by Troedsson. The ventral surface of the conch appears to have been moderately convex, and the lateral angles appear to have been acute.

Locality and horizon.—Swift Point, Narrows, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. No. 6804, Victoria Memorial Museum.

Remarks.—As a matter of fact, the specimen is too poorly preserved to be identified with confidence, but it is sufficient to indicate the presence of a true *Lambeoceras* in the Dog Head member of the Red River formation.

A similar specimen, more poorly preserved, but probably belonging to the same species, was found on Berens Island, Lake Winnipeg; also in the Dog Head member.

WINNIPEGOCERAS Foerste

Genotype: *Cyrtoceras laticurvatum* Whiteaves, Geol. Surv. Canada, Pal. Foss. 3, pt. 3, 224, text fig. 14 (1897); *Winnipegoceras laticurvatum* Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, no. 3, 56, pl. 9, figs. 1, 2.

Conch strongly curved lengthwise, with the ventral outline convex and the dorsal outline concave. In the genotype the conch is slightly humped along its ventral outline at a point five or six camerae below the base of the living chamber, and this chamber is long and attenuated. The sutures of the septa curve

strongly downward laterally. The siphuncle is located near the ventral wall of the conch, and its segments enlarge conspicuously within the camerae.

With this genotype are associated tentatively 4 species, none of which have an equally long living chamber, and in none of which the structure of the siphuncle is known. However they agree in their lengthwise curvature; in their attenuation from a point several camerae beneath the living chamber as far up as the aperture, and in the downward curvature laterally of the sutures of the septa. These 4 species are as follows:

Westonoceras (?) *contractum* Foerste and Savage,[5] from the Shamattawa limestone on the Shamattawa river, southwest of Hudson Bay.

Westonoceras (?) *tumidum* (Schuchert),[6] from the Ordovician strata at the head of Frobisher Bay, in the southeastern part of Baffin Land.

Winnipegoceras dowlingi Foerste,[7] from the equivalent of the Red River formation on Putnam Highland, east of the northern margin of Foxe Land, on the southwestern side of Baffin Land.

To this is added the specimen described here under *Winnipegoceras* (?) sp., from the bay between Cat Head and McBeth Point.

37. Winnipegoceras laticurvatum (Whiteaves)

Cyrtoceras laticurvatum Whiteaves, Geol. Surv. Canada, Pal. Foss., 3, pt. 3, 224, text fig. 14 (1897).

Winnipegoceras laticurvatum Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, 56, pl. 9, figs. 1, 2 (1928).

Locality and horizon.—Little Black island, Jackfish island, and point off Moose creek 8 miles southwest of Whiteway point, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. Specimens No. 7148 (type), 7148a, and 7153, Victoria Memorial Museum.

[5] Foerste, Aug. F., and Savage, T. E. Jour. Sci. Lab. Denison Univ., 22, 55, pl. 16, figs. 2A, B (1927).

[6] Foerste, Aug. F. Jour. Sci. Lab. Denison Univ., 23, 102, pl. 8, figs. 7A, B (1928).

[7] Foerste, Aug. F. Contrib. Mus. Pal. Univ. Michigan, 3, 58, pl. 8, fig. 1 (1928).

38. **Winnipegoceras dowlingi** Foerste

Winnipegoceras dowlingi Foerste, Contrib. Mus. Pal., 3, 58, pl. 8, fig. 1 (1928).

Locality and horizon.—Little Tamarack island, in Lake Winnipeg; in the Lower Mottled or Dog Head member of the Red River formation. Specimen No. 7152 in the Victoria Memorial Museum, Ottawa, Ontario, Canada.

39. **Winnipegoceras** (?) sp. (Near McBeth Point)

Plate XVI, fig. 6

Fragment 33 mm. long, consisting of a living chamber with two camerae still attached. The length of the living chamber is 25 mm., measured from the lowest part of the suture of the septum at its base to the aperture. At this suture the dorso-ventral diameter of the conch is 24 mm., narrowing to 16 mm. at the aperture. The largest dorso-ventral diameter probably was several camerae below the base of the living chamber. The sutures of the septa curve strongly downward laterally, the depth of the resulting lobe being 4 mm. at the base of the chamber. The ventral saddles rise somewhat higher than the dorsal ones. The cast of the interior of the conch is marked by faint transverse ribs which curve rather strongly downward ventrally along the lower part of the specimen, but only slightly so at its upper end, the margin of the aperture being almost straight. The siphuncle evidently was located near the convex or ventral outline of the conch.

Locality and horizon. Bay between Cat Head and McBeth Point, Lake Winnipeg; in the upper or Selkirk member of the Red River formation. Specimen No. 5648, Victoria Memorial Museum.

OXYGONIOCERAS Foerste

Genotype: *Trochoceras oxynotum* Barrande, Systeme Silurien du Centre de la Boheme, 2, 91, pl. 14, figs. 1–11 (1867); *Oxygonioceras oxynotum* Foerste, Jour. Sci. Lab. Denison Univ., 21, 62 (1925); 21, 375, pl. 42, figs. 1 A–E (1926).

The cross-section of the conch of this genotype is ovate in outline, with the ventral part strongly, but not sharply acute, and the dorsal part distinctly rounded.

In the Manitoban specimen here described under the name *Oxygonioceras* (?) *latum*, the ventral side of the cross-section of the conch is sharply acute, and the dorsal part also is acute, at least in the present state of preservation of the specimen. Evidently, the Manitoban specimen here described can not belong to *Oxygonioceras*, but it appears more closely related to that genus than to any other described so far. Its reference to *Oxygonioceras* is only tentative, awaiting further knowledge of its structure, especially the structure of its siphuncle.

40. **Oxygonioceras** (?) **latum** Sp. nov.

Plate XVIII, figs 1, 2

Conch curved lengthwise, with the concave vertical dorsal outline undulating at regular intervals. Cross-section lenticular, with the ventral end of this section much more sharply acute than its dorsal end. The specimen consists of a part of a phragmacone, 160 mm. long, and includes 26 camerae. Its dorso-ventral diameter at the eighteenth camera beneath its top is 83 mm., apparently increasing to about 90 mm. at its upper end. Its lateral diameter at the upper end of the specimen is 27 mm., the maximum lateral diameter being located 30 mm. from the dorsal side of the conch, and therefore distinctly dorsad of the center of the conch. The siphuncle is located between 5 and 7 mm. from the ventral outlines of the conch. Its segments are at least 2.5 mm. in diameter dorso-ventrally, but in a lateral direction they are strongly flattened by pressure. Apparently these segments are elongated in a narrowly elliptical manner, somewhat as in species of *Cyrtorizoceras*, but little definite information is presented by the specimen at hand.

Locality and horison.—From some unknown locality in southern Manitoba; in the Dog Head member of the Red River formation. Specimen No. 7154.

Second specimen.—Specimen consisting of a living chamber and

of the upper 16 camerae of the phragmacone. The vertical dorsal outline, as far as preserved, has a radius of curvature of 60 mm. There are no traces of undulations here as in the preceding specimen. The ventral vertical outline of the conch is not preserved. Its cross-section is assumed to have been lenticular. The number of camerae in a length equal to the present dorso-ventral diameter of the conch equals 15, when counted along the middle of the lateral side of the specimen. The sutures of the septa curve strongly downward laterally, the resulting lateral lobes having a depth of 23 mm. The ventral saddles rise higher than the dorsal ones. No trace of the siphuncle is preserved. Specimen No. 7151a.

Third specimen.—Specimen 115 mm. long, consisting of a living chamber and of the upper 8 camerae of the phragmacone. The living chamber rises 60 or 65 mm. above the lowest part of the suture at its base. The ventral outline is well preserved, and the cross-section of this part of the conch is sharply acute, as in the specimen described first. At the base of the specimen, corresponding in position to its ninth camera from the top, there appears to be a single segment of the siphuncle, but it may be something else. The ventral part of the specimen is weathered away. Specimen No. 7151.

All three specimens are from the same locality and horizon.

Remarks.—The reference of these specimens to *Oxygonioceras* is only tentative. The very strong lateral compression of the siphuncle in the specimen described first, and here regarded as the type, suggests that the conch also is strongly compressed laterally. The form of the segment of the siphuncle suggested by the third specimen is unlike that indicated by the first. So much remains doubtful after studying all three specimens that it seems inadvisable to use them as types of a new genus.

WESTONOCERAS Foerste

Genotype: *Cyrtoceras manitobense* Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 80, pl. 13, figs. 3, 4, 5; pl. 15, fig. 4 (1890); *Westonoceras manitobense* Foerste, Journ. Sci. Lab. Denison Univ., 20, 253 (1924); Contrib. Mus. Pal. Univ. Michigan, 3, 49, pl. 5, fig. 1; pl. 11, fig. 5 (1928).

Westonoceras includes *Westonoceras manitobense* (Whiteaves) from southern Manitoba; *Westonoceras putnami* Foerste, from Putnam Highland, east of the north shore of Foxe Land, in southwestern Baffin Land; *Westonoceras gouldi* Foerste, also from Putnam Highland; and *Westonoceras nelsonense* Foerste from the Nelson River southwest of Hudson Bay.

The precise relationship of *Westonoceras latum* Troedsson, from the northwestern part of Greenland, can not be determined at present. The course of the sutures of the septa is essentially straight, differing in this respect from typical *Westonoceras* and also from typical *Winnipegoceras*.

41. **Westonoceras manitobense** (Whiteaves)

Plate XXXVIII, figs. 2, 3

Cyrtoceras manitobense Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 80, pl. 13, figs. 3, 4, 5; pl. 15, fig. 4 (1890).

Westonoceras manitobense Foerste, Jour. Sci. Lab. Denison Univ., 20, 253 (1924); Contrib. Mus. Pal. Univ. Michigan, 3, no. 3, 49, pl. 5, fig. 1; pl. 11, fig. 5 (1928).

Selected type.—Specimen 128 mm. long. The vertical axis of the conch is slightly curved. The convexity of the ventral outline equals 15 mm. and is greatest between 5 and 7 camerae beneath the base of the living chamber, forming there a distinct hump, above and below which the outline is nearly straight. Opposite this ventral hump, the dorsal outline is faintly gibbous. Immediately beneath the aperture of the living chamber this dorsal outline is slightly concave. The dorso-ventral diameter lessens from 42 mm. at the hump to 29 mm. at the aperture. The cross-section of the middle and upper part of the specimen has been distorted considerably by oblique lateral pressure, but the lower part shows distinctly the lateral compression of the conch, its dorso-ventral diameter 7 camerae above its base being 21.5 mm., while its lateral diameter is 19.5 mm. There is a distinct angularity along the median line of the ventral side, while the dorsal side of the cross-section is evenly convex. The sutures of the septa curve distinctly downward laterally, even at early

stages of growth. Along the middle and upper parts of the phragmacone the lowest part of this downward curvature is distinctly ventrad of the center of the conch. Dorsally from this point the sutures are almost straight, rising evenly as far as the dorsal outline of the conch. Ventrally, however, these sutures curve increasingly upward, especially along the upper part of the phragmacone. Along the median line of the ventral side of the conch the ventral saddles are distinctly angular, while the dorsal saddles are broadly rounded. Along the lower part of the phragmacone the crests of the ventral saddles tend to be slightly lower in elevation than those of the dorsal ones, but along its upper part the reverse is the case, the ventral saddles being distinctly higher. Where the dorso-ventral diameter of the conch is 26 mm., the center of the siphuncle is located 6 mm. from the ventral wall of the conch and its maximum diameter within the camerae is 6 mm., contracting to 5.5 mm. where the connecting rings come in contact with the septa above and beneath, and to 2.5 mm. at the passage of the siphuncle through the septa. A deposit of calcite embraces the inner margin of these septa, within the siphuncle, this deposit frequently being thicker along the lower side of the septum than on its upper side. The inner margin of these septa terminates abruptly, without curving downward into a neck. The vertical outline of the connecting rings is slightly convex or almost straight, except where approaching contact with the septa above and beneath, where their convexity is relatively short but distinct. A thin deposit of calcite often covers the outer surface of the connecting rings. When this deposit fills in the angle between ends of the connecting rings and the adjoining septa, the vertical outline of the connecting rings at first sight appears straight along its entire length.

Locality and horizon.—Big Island, Lake Winnipeg. From the lower or Dog Head member of the Red River formation. Specimen No. 1879, Victoria Memorial Museum. Figured in Contrib. Mus. Pal. Univ. Michigan, 3, pls. 5, 11 (1928).

Bull Head specimen.—Specimen 125 mm. long; dorso-ventral diameter at the hump along the ventral outline 45 mm., contracting to 27 mm. at the aperture of the living chamber. Length

of living chamber about 60 mm., measured from the lowest part of the lateral lobes of the suture of septum at its base. The hump along the ventral outline is at the eighth camera beneath this chamber. The maximum part of the dorsal gibbosity is at the sixth and seventh camerae beneath the chamber. The dorsal outline of the living chamber has a concavity of 2 mm. At the base of the specimen, and also at the top of the phragmacone, the siphuncle is 3 mm. distant from the ventral wall of the conch, but this distance increases to 6 mm. at the ventral hump. The dorso-ventral concavity of the septa increases toward the top of the phragmacone, equalling 14 mm. at the base of the living chamber. Both the dorsal and ventral vertical outlines of the segment of the siphuncle included in the second camera beneath the living chamber are distinctly convex, but these convexities are much less in the immediately underlying segments. Along the lower part of the specimen the ventral vertical outlines of the segments are virtually straight. They appear to be straight also along the greater part of the length of the dorsal vertical outlines, though convex at the base of each segment, where coming in contact with the segment beneath. In the first and third segments from the base of the specimen the vertical outlines along the dorsal side of the segments are abruptly convex at immediate contact with the overlying septa. From Bull Head, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. Specimen No. 1883, Victoria Memorial Museum. Plate XXXVIII, fig. 2.

The specimen represented by figure 4 on plate 13 of the publication by Whiteaves cited above was missing before the first catalogue of the specimens belonging to the Victoria Memorial Museum was prepared.

Grindstone Point specimen.—Specimen 16.5 mm. long, including 6 camerae. Dorso-ventral diameter at top of specimen 26 mm.; lateral diameter, 23 mm. Center of siphuncle 5.5 mm. from ventral wall of conch. Diameter of siphuncle at top of specimen, in a direction parallel to the septa. 16 mm. Passage of siphuncle through the septa, 2.5 mm. in diameter. The inner margins of these septa end abruptly, without any downward

curvature into a neck. The vertical outlines of the segments of the siphuncle are only slightly convex ventrally and tend to be almost straight dorsally, except where approaching contact with the septa immediately above or beneath. These vertical outlines tend to be more convex along the upper part of the ventral side of the connecting rings, and along the lower part of their dorsal side. From a locality between Big and Little Grindstone Points, Lake Winnipeg, from the same horizon as the preceding. Specimen No. 6829, Victoria Memorial Museum. Plate XXXVIII, fig. 3.

Thuleoceras ornatum Troedsson.—This species was described by Troedsson[8] from the Cape Calhoun beds of northwestern Greenland. The structure of its siphuncle is similar to that of *Westonoceras* as figured in the Contrib. Mus. Pal. Univ. Michigan, 3 (1928), on Plate 11. However, in the absence of any knowledge of the upper part of the conch of the Greenland species it is impossible to determine which of the species of *Westonoceras*, among those already described, it resembles most.

42. **Westonoceras nelsonense** Sp. nov.

Plate XXXVIII, fig. 1

Cyrtoceras manitobense Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, 223 (1897).

Cf. *Westonoceras* sp., Foerste and Savage, Jour. Sci. Lab. Denison Univ., 22, 54, pl. 18, figs. 1 A, B (1927).

Specimen 160 mm. long, of which length 65 mm. belongs to the living chamber, when measured up from the lowest part of the septum at the base of the chamber. The conch is compressed somewhat obliquely in a dorso-ventral direction, and, in its present condition, the maximum lateral diameter is greater than the dorso-ventral one, these measurements being 60 mm. and 49 mm. respectively. Originally, however, judging from undistorted specimens of this genus, the dorso-ventral diameter must have

[8] Troedsson, Gustaf. On the Middle and Upper Ordovician Faunas of Northern Greenland, Gustaf T. Troedsson, Jubilaeumsekspeditionen Nord om Grønland 1920–23, nr. 1, 94, pl. 1, figs. 3, 4; pl. 55, figs. 4–9 (1926).

been the greater one, though possibly only to a moderate degree. The maximum diameter of the conch, in its present condition, is located at the base of the fifth camera beneath the living chamber. From here it narrows to 50 mm. at the base of this chamber, and to approximately 34 mm. at the top of the specimen. The ventral outline of the conch is convex, but its curvature is slight except in the immediate vicinity of the maximum diameter of the conch. The dorsal outline apparently was nearly straight, but with a slight convexity or gibbosity for a total length of 6 camerae in the immediate vicinity of the greatest diameter of the conch. Above this gibbosity, the dorsal outline of the top of the phragmacone and of the entire living chamber may have been faintly concave. Ten camerae occur in a length equal to the maximum diameter of the conch, when counted downward from this diameter. Originally the sutures of the septa had a course similar to those of *Westonoceras gouldi* Foerste,[9] from Putnam Highland, east of the northern end of Foxe Land, in southwestern Baffin Land. Ventrally they rise into low saddles which are distinctly angular along their median part. In the present condition of the specimen, the center of the siphuncle is 17.5 mm. from the ventral wall of the conch where the dorso-ventral diameter of the conch is 46 mm. The uppermost segment exposed is 12.2 mm. in diameter where its height is 6 mm. It contracts to a diameter of 10 mm. where it comes in contact with the septum above and below. The passage of the siphuncle through the septum contracts to a diameter of 5.1 mm. The inner margin of this septum ends abruptly, without any downward curvature into a neck; on the contrary, the septum rises slightly between its first contact with the outer part of the connecting rings and its inner margin. A deposit of calcite encircles the inner margin of the septa, this deposit being thin on the upper side of the septa, but thicker beneath. The cast of the interior of the conch is faintly ribbed vertically, about 8 ribs occurring in a width of 20 mm. where the present maximum diameter of the conch is 46 mm. Such ribs are found on the surface of casts of the interior of many nautiloid

[9] Foerste, Aug. F. Contrib. Mus. Pal. Univ. Michigan, vol. 3, pl. V, fig. 2 (1928).

conchs, especially of those ordinarily called gomphoceroid or phragmoceroid. No trace of surface markings of the shell is preserved.

Locality and horizon.—At the second rapid of the Nelson River; in the Nelson limestone, an equivalent of the Red River formation. Collected by Robert Bell in 1879. Specimen No. 7147, Victoria Memorial Museum.

The specimen figured by Foerste and Savage, in the publication cited above, from the same locality and horizon, appears to be another specimen of the same species, also flattened dorso-ventrally, but with the ventral side weathered away. However, it is closely similar in the relative length of the camerae, compared with the lateral diameter of the specimen.

Remarks.—*Westonoceras nelsonense* is distinct from the other species of *Westonoceras* described so far in its larger size and in its relatively tall camerae. Compared with the diameter of the conch, the number of camerae is relatively less.

DIESTOCERAS Foerste

Genotype: *Gomphoceras indianense* Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, 137, pl. 7, figs. 3–5. *Diestoceras indianense* Foerste, Jour. Sci. Lab. Denison Univ., 20, 263, pl. 25, figs. 1 A, B; pl. 26, figs. 1 A, B, 2 A, B; pl. 27, fig. 2.

One of the characteristic features of this genotype is the distinct downward curvature of its transverse striae along the ventral side of the conch, indicating the presence of a very shallow hyponomic sinus, with a tendency toward a distinct angulation along the median line of this side.

None of the Manitoban species here referred to *Diestoceras* are known to possess such a shallow hyponomic sinus. In fact, transverse striae are known in only one of these Manitoban species; namely in *Diestoceras nobile*, and in that case only along its dorsal side. Moreover the infolding of the margin of the aperture of the two specimen illustrated on plate XXV of this journal requires explanation.

43. **Diestoceras nobile** (Whiteaves)

Plate XXXVI, fig. 1

Poterioceras nobile Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 77, pl. 14, fig. 1 (1890).

Specimen 150 mm. long, its lateral diameter enlarging from 54 mm. at its base to 125 mm. at the top of the phragmacone, diminishing thence to 59 mm. at the margin of the aperture. The lateral outlines of the conch are rather evenly convex along the greater part of the length of the conch, except along its lower part where the curvature of these outlines is slight. The specimen evidently is compressed dorso-ventrally, its present dorso-ventral diameter being estimated at 102 mm. The septum at the base of the living chamber is distinctly exposed along the left side of the specimen. The cast of the interior of this chamber is vertically ribbed and grooved as in many other species of gomphoceroids and poterioceroids. Faint traces of septa along the left lateral side of the phragmacone suggest the presence of 3 camerae in a length of 30 mm. between 40 and 70 mm. beneath the living chamber. The siphuncle appears to be located very close to the ventral wall of the conch, but nothing is known of its structure. The thickness of the shell is 2 mm. at the base of the living chamber, and thins from this point both upward and downward. The surface of the shell is very smooth, but with numerous low and faint transverse lines, of which 11 occur in a length of 20 mm.

Locality and horizon.—East Selkirk, Manitoba; in the upper or Selkirk member of the Red River formation. Specimen No. 1885, Victoria Memorial Museum.

44. **Diestoceras** (?) **whiteavesi** Sp. nov.

Plate XXXV, figs. 2, 3; Plate XXVI, fig. 4

Poterioceras apertum Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 87, pl. 11, fig. 2; possibly also 7, sec. 4, pl. 14, fig. 3.

Specimen 83 mm. long, with a lateral diameter of 51 mm. at the level of the highest septum preserved, but continuing to enlarge

to 54 mm. at a level 18 mm. farther up. Thence it contracts to 32 mm. at the crest of the infolding wall of the living chamber at its aperture. Judging from the vertical section of the conch produced by the weathering away of its ventral side, the infolded margin of the upper wall of the chamber extends inward about 3 mm. from this crest, leaving 26 mm. for the dorso-ventral diameter of the aperture itself. The dorso-ventral diameter of the conch, previous to weathering, is estimated at 48 mm. The conch in its present state evidently is depressed dorso-ventrally, but originally the compression may have been in a lateral direction. The sutures of the septa at the top of the phragmacone slope downward at an angle of 5 degrees with the horizontal toward that side of the conch near which the siphuncle is located. The uppermost camera is 2.5 mm. long and the cast of its interior appears to be vertically ribbed. The underlying 3 camerae have a total length of 14 mm., and the next 3 of 12 mm. The siphuncle is exposed by weathering along the ventral side of the specimen. The uppermost segment preserved exposes a width of 8 mm. where the height of the camera is 4.5 mm., and where the distance of the siphuncle from the ventral wall of the conch probably was about 1 or 1.5 mm. This uppermost segment of the siphuncle apparently was disk-like nummuloidal in form. The septum at the base of the specimen is 23 mm. in diameter, its concavity is 5 mm., and its angulation with the lateral walls of the conch is so slight as not to be immediately perceptible. The shell is about 1.5 mm. thick. The surface of the shell, as far as known, appears to be smooth.

Locality and horizon.—Black Island, Swampy harbour, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 1887, Victoria Memorial Museum. Original of Whiteaves fig. 2, on plate 11, cited above; also of fig. 2 on plate XXXV of the present publication.

Dog Head specimen.—Specimen differing from the preceding chiefly in its smaller size, its length being 66 mm. It is mature, however, as indicated both by the relatively short length of its uppermost camerae, and by the contraction of its living chamber toward its aperture. It agrees with the preceding specimen in

its relatively short camerae, and in the enlargement of the conch to a point about two-sevenths of the length of the living chamber above its base. It is interesting in showing a slightly more convex vertical outline on one side of the specimen than on the opposite side, but the sutures of the septa slope downward at an angle of 5 degrees in a direction at right angle to a plane including the two vertical outlines just mentioned. The septum at the base of the specimen is 17 mm. in diameter and 3.5 mm. in concavity. The septa are preserved for a distance of 2 or 3 mm. from the walls of the conch on both sides of the specimen. Along the more strongly convex vertical outline, they slope downward at an angle of 40 degrees with the horizontal. On the opposite side the septa are more nearly horizontal, and these terminate at approximately the same lengths, their inner terminations suggesting very short septal necks, but too vague to definitely locate the position of the siphuncle, whose real location may be in quite a different position. Dog Head, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 1889, Victoria Memorial Museum. Original of Whiteaves's fig. 3 on plate 14, cited above; also of fig. 3 on plate XXXV of the present publication.

Remarks.—*Diestoceras whiteavesi* is similar to *Diestoceras schucherti* Foerste, from the head of Frobisher Bay in the southern part of Baffin Land in the strong concavity of its septa, the nummuloidal character of its siphuncle, and in the location of this siphuncle almost in contact with the ventral wall of the conch. *Diestoceras obesum* (Billings), from the English Head member of the Richmond on Anticosti Island, is another specimen with deeply concave septa, but nothing is known of its siphuncle.

45. **Diestoceras** (?) sp. (Black Island)

Plate XXXV, fig. 1

Poterioceras apertum Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, 87, pl. 11, fig. 3.

Specimen 87 mm. long, with an estimated lateral diameter of 69 mm. in the present condition of the specimen. This maximum

diameter is located two-fifths of the length of the living chamber above its base. The sutures of the septa slope downward toward that side of the conch which is partially weathered away. The upper part of the walls of the living chamber appears to curve strongly inward and downward. The crest of this incurvature outlines a circular area 45 mm. in diameter, the aperture itself having a diameter of 31 mm. The thickness of the shell along the lower part of the living chamber is 2 mm., increasing to 3 mm. along its upper part. No trace of the siphuncle can be detected. The chief difference between this specimen and those described under *Diestoceras whiteavesi* is the relatively greater length of its camerae, the latter numbering 3 in a total length of 21 mm. Moreover, the phragmacone enlarges more rapidly, so that the upper part of the conch is relatively wider.

Locality and horizon.—Black Island, Swampy harbour, Lake Winnipeg, Manitoba; in the lower or Dog Head member of the Red River formation. No. 1887a, Victoria Memorial Museum.

46. **Diestoceras gibbosum** Sp. nov.

Plate XXXV, fig. 4

Specimen 83 mm. long, enlarging from a lateral diameter of 36 mm. to 74 mm. at the base of the living chamber which is 53 mm. farther up, and then contracting to a diameter estimated at 52 mm. at the uppermost part of the living chamber preserved, which is 30 mm. above the suture at its base. The sutures of the septa are directly transverse. The uppermost camera is distinctly shorter than those directly beneath. The underlying camerae have a vertical height of 6 mm., which becomes slightly longer when measured along the rapidly expanding part of the phragmacone. The septa appear to have been deeply concave but nothing is known of the location of the siphuncle. At right angles to the maximum diameter of the conch, at the base of the living chamber, its minimum diameter is estimated at 58 mm. The specimen evidently has been compressed by pressure subsequent to the death of the animal.

Locality and horizon.—Tyndall, Manitoba; from the upper or

Selkirk member of the Red River formation. No. 5609, Victoria Memorial Museum.

Remarks.—This specimen resembles *Diestoceras strangulatum* Foerste, from the Vaureal formation on Anticosti Island in the shortness of its living chamber, its greatest diameter being near the base of this chamber rather than along the upper part of the phragmacone.

47. **Diestoceras apertum** (Whiteaves)

Plate XXXVII, fig. 1

Poterioceras apertum Whiteaves, Trans. Royal Soc. Canada, 7; sec. 4, 78, pl. 14, fig. 2; but not figs. 3, 4 (1890); also not 9, sec. 4, 87, pl. 11, figs. 2, 3 (1892).

Two specimens were figured by Whiteaves in his original description of *Poterioceras apertum*; one from Swampy Island, and the second from Dog Head. The Swampy Island specimen here is selected as the type of the species, both because it is the one figured first on the plate cited and because more is known regarding its structure.

Selected type.—Specimen 122 mm. long, slightly curved lengthwise at its apical end and strongly compressed laterally; largest in diameter at the top of the phragmacone, tapering thence toward the aperture of the living chamber. Viewing the specimen from one of its lateral sides, one of the vertical outlines is convex along its entire length, while the opposite vertical outline is distinctly more convex along the living chamber and the upper part of the phragmacone, but reverses to faintly concave along the lower part of the phragmacone. Associated with this difference in the two vertical outlines of the conch is a difference in the slope of the sutures of the septa. At the top of the phragmacone these sutures slope downward at an angle of about 7 degrees with the horizontal from that side of the conch which is convex along its entire length toward the opposite side of the conch. Six camerae beneath the living chamber these sutures become strictly horizontal. At the base of the specimen they rise slightly in the same direction, namely toward that side of the conch which

is faintly concave along the lower part of the specimen. The cast of the interior of the conch enlarges dorso-ventrally from a diameter of 27 mm. at its base to 70 mm. at the top of the phragmacone, and then diminishes to 57.5 mm. at the aperture. The corresponding lateral diameters are 21 mm., 59 mm., and 48 mm., but these lateral diameters have been shortened in part by compression previous to fossilization. The height of the living chamber is 37.5 mm. along that side of the conch which is convex along its entire length, and 43 mm. along its opposite side. The cast of the interior of the uppermost camera is distinctly ribbed vertically, and that of the camera next beneath is ribbed faintly. The septum at the base of the specimen apparently is strongly concave. No trace of the siphuncle can be detected here. The thickness of the shell appears to vary between 2 and 3 mm. along the living chamber. The surface of the shell is striated transversely by low lines which are parallel to the sutures along the lateral sides of the conch and also along that side which is convex along its entire length. Along the opposite side of the conch, where the vertical outline is concave toward its base, the course of the transverse striae can not be determined.

Locality and horizon.—Swampy Island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. No. 1888, Victoria Memorial Museum.

Troedsson described and figured two specimens under the name *Cyrtogomphoceras stensioei*, both from the Lyckholm of Esthonia. The type[10] is from Ranaküll at Hapsal. A second specimen, identified as belonging to the same species, is figured from Piersal. The type appears to be endogastric in structure. Its antisiphuncular outline is convex along its entire length. However, that outline which is nearest the siphuncle is convex only along the living chamber and the upper part of the phragmacone, but along the lower part of the specimen this outline becomes distinctly, but feebly concave. In keeping with this endogastric location of the siphuncle, the sutures of the septa are more closely crowded

[10] Troedsson, Gustaf. On the Middle and Upper Ordovician Faunas of Northern Greenland, 108, pl. 63, fig. 5; pl. 64, figs. 1, 2 (1926).

along the siphonal part of the conch than along its opposite outline.

CYRTOGOMPHOCERAS Foerste

Genotype: *Oncoceras magnum* Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 79, pl. 15, fig. 1 (1890); *Cyrtogomphoceras magnum* Foerste, Jour. Sci. Lab. Denison Univ., 20, 267 (1924); Contrib. Mus. Pal. Univ. Michigan, 3, 59, pl. 6, fig. 1 (1928).

In typical *Cyrtogomphoceras* the location of the siphuncle is endogastric. The dorsal outline is conspicuously convex, and the ventral outline is concave along the lower part of the phragmacone, but distinctly though moderately gibbous along the upper part of the phragmacone and the lower part of the living chamber.

From this type of structure *Cyrtogomphoceras intermedium* (Whiteaves) differs in having its ventral outline slightly concave along its entire length. In other respects, however, it appears to be closely similar.

48. Cyrtogomphoceras magnum (Whiteaves)

Oncoceras magnum Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 79, pl. 15, fig. 1 (1890).

Cyrtogomphoceras magnum Foerste, Jour. Sci. Lab. Denison Univ., 20, 267 (1924); Contrib. Mus. Pal. Univ. Michigan, 3, 59, pl. 6, fig. 1 (1928).

Locality and horizon.—East Selkirk, Manitoba; in the Selkirk member of the Red River formation. No. 1875, Victoria Memorial Museum.

49. Cyrtogomphoceras whiteavesi (Miller)

Oncoceras gibbosum Whiteaves (not Hall, 1847), Trans. Royal Soc. Canada, 7, sec. 4, 80, pl. 15, figs. 2, 3 (1890).

Oncoceras whiteavesi Miller, North Amer., Geol. Pal., 1st App., 697 (1892).

Cyrtogomphoceras whiteavesi Foerste. Contrib. Mus. Pal. Univ. Michigan, 3, 61, pl. 7, figs. 1, 2, 3 (1928).

Locality and horizon.—Pike Head or Jackfish bay, Swampy island, Big island, Washow bay, and Bull Head bay, Lake Winnipeg, Manitoba, in the lower or Dog Head and middle or Cat Head members of the Red River formation. Specimen No. 1877, Victoria Memorial Museum.

50. **Cyrtogomphoceras** cf. **turgidum** Troedsson

Cyrtogomphoceras turgidum Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland; part I, Cephalopods, 97, pl. 2, fig. 2; pl. 57, figs. 1, 2; pl. 58, figs. 2–4.

Locality and horizon.—North end of Big island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. No. 7144, Victoria Memorial Museum.

51. **Cyrtogomphoceras** (?) **intermedium** (Whiteaves)

Oncoceras (*magnum* ? var.) *intermedium* Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 3, 221, 222, text fig. 13 (1897).

Cyrtogomphoceras intermedium Foerste, Contrib. Mus. Pal. Univ. Michigan, 3, 65, pl. 8, fig. 2 (1928).

Locality and horizon.—Black island, Lake Winnipeg; in the lower or Dog Head member of the Red River formation. No. 7143, Victoria Memorial Museum.

REEDSOCERAS Gen. nov.

Genotype: *Cyrtoceras macrostomum* Hall, Pal. New York, 1, 194, pl. 42, figs. 1 b, c (1847).

The species *Cyrtoceras macrostomum* Hall was used by me as the genotype of *Conradoceras* [Jour. Sci. Lab .Denison Univ., 23, 208 (1928)]. However, this generic term had been used by me before [*ibid.*, 21, 361 (1926)], for phragmoceroid conchs, with *Phragmoceras pseudoconradi* Foerste as the genotype. This phragmoceroid was figured by Barrande, in his Systeme Silurien du Centre de la Boheme, 2, 209, pl. 49, figs. 4–7 only, under the name *Phragmoceras conradi*. From the typical form of this species the specimen used as the genotype of the first published form of *Conradoceras* was distinguished specifically by the present writer under the name *pseudoconradi*. The generic term *Conrado-*

ceras being preoccupied. It, therefore, has become necessary to abandon the use of the name *Conradoceras* for the species *Cyrtoceras macrostomum*, and the generic term *Reedsoceras* is proposed instead for this Ordovician species, in honor of Dr. Chester A. Reeds, of the American Museum of Natural History, who for many years has made available for study the wonderful collections of fossils under his charge.

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PLATE XI

N.B.—All specimens on this and the following plates are from the Victoria Memorial Museum unless otherwise stated.

Fig. 1. *Cyclendoceras whiteavesi* Foerste. Dorsal side, showing thick shell with numerous annulations; also the relatively numerous camerae. Southeast point of Berens island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 5599. Figure 0.83 of natural size.

1

PLATE XII

Fig. 1. *Endoceras manitobense* Foerste. Specimen weathered so as to show the ventro-lateral side of the siphuncle. The septal necks of the latter are not conspicuously annulated as in many other species of *Endoceras*. Biscuit point, Narrows, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 6800. Figure 0.81 of natural size.

Fig. 2. *Cyclendoceras kindlei* Foerste. Lateral view of conch, with imperfect ventral outline on right. Between second and third rapids up Nelson River, southwest of Hudson Bay; in the Nelson limestone. Specimen No. 1840. Figure 0.85 of natural size. See also plate XXII, fig. 2.

1

2

PLATE XIII

Fig. 1. *Billingsites costulatum* (Whiteaves). A, Dorsal view. B, Lateral view, with dorsal side on right. C, Lateral view, with dorsal side on left. The lateral views show the course of the suture at the base of the specimen, and part of the course of the three conspicuous upper lobes. All three views show traces of the transverse striae on the surface of the shell, these striae curving downward toward the dorsal side of the specimen, as shown best by figure C. Black island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7142.

Fig. 2. *Dowlingoceras gracile* (Whiteaves). A, Lateral view, with ventral side on right. B, Cross-section, showing location of siphucle, C, vertical section of siphuncle near top of phragmacone, magnified 2 diameters. Black island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1841.

Fig. 3. *Whitevesites winnipegensis* (Whiteaves). Dorsal view. Black island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1830. See also pl. XIV, figs. 1A, B; pl. XXVI, fig. 2.

1A

2A

2B

2C

1B

1C

3

PLATE XIV

Fig. 1. *Whiteavesites winnipegensis* (Whiteaves). A, Lateral view, with ventral outline on left; all but the upper two camerae of the phragmacone sectioned vertically to show the structure of the siphuncle. B, Lateral view of opposite side of specimen, retaining parts of the shell. Black island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1830. See also pl. XIII, fig. 3; pl. XXVI, fig. 2.

Fig. 2. *Paractinoceras canadense* (Whiteaves). Ventral view; the basal part of the specimen, as figured by Whiteaves, no longer can be found. All but the upper three camerae of the phragmacone have been sectioned vertically to show the structure of the siphuncle; the latter is typically actinoceroid along the lower part of the specimen, but toward the top of the phragmacone the segments of the siphuncle lose their nummuloidal form and become vertically elongate with elliptical outlines. No calcareous deposits occur within this siphuncle. Swampy or Berens island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1839. See also plate XXVI, figs. 3A, B.

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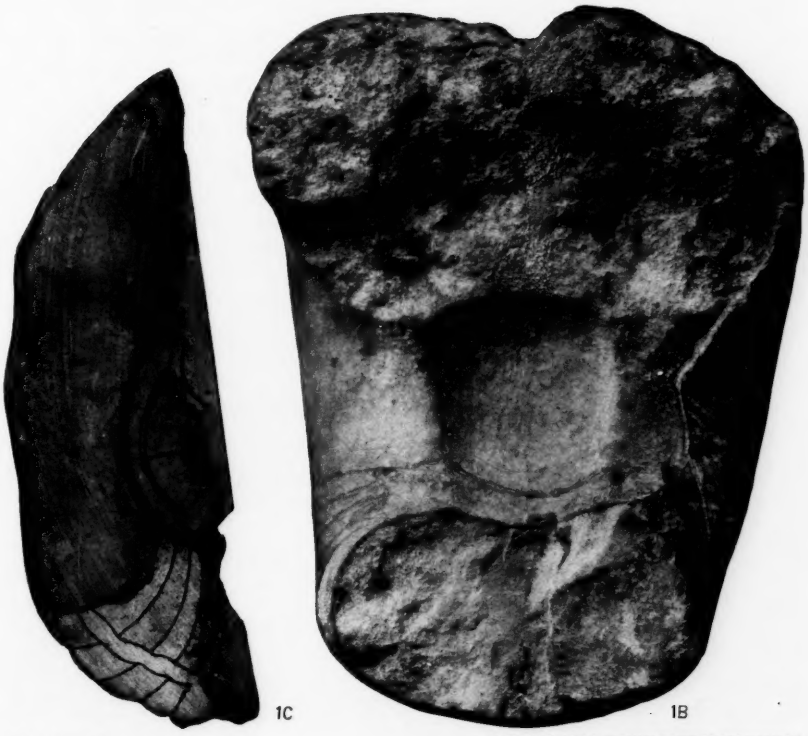
PLATE XV

Fig. 1. *Charactoceras* (?) *plicatum* (Whiteaves). A, lateral view, with the base of the living chamber indicated by the arrow, the larger end of this chamber being at the left. The transverse ribs curve strongly downward along the ventro-lateral sides of the conch, their downward course being continued by the transverse striae which are parallel to the ribs as far as the latter extend. Owing to distortion of the specimen by dorso-ventral compression the course of these ribs has been altered to nearly directly transverse at the upper end of the living chamber. B, dorsal view of living chamber and adjacent part of phragmacone of same specimen, showing dorsal impressed zone: also indication of suture of septum at the base of the living chamber. C, dorso-ventral section of same specimen, showing structure of the siphuncle within the four camerae at the top of the phragmacone, also location of the siphuncle along that part of the next inner volution which is in contact with the lower part of the dorsal side of the living chamber. Black Island, Swampy harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7155.

1A



1C 1B

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PLATE XVI

Fig. 1. *Charactoceras plicatum* ? (Whiteaves). Lateral view, the base of the living chamber being located at the point indicated by the arrow. The downward curvature of the lateral ribs is indicated best by the upper three ribs on the left side of the figure; the ventral extension of the lower ribs of this figure appears to have been incorrectly accentuated by some one attempting to clean the specimen. The large opening through the umbilical depression apparently was the work of the same cleaner. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 7160.

Fig. 2. *Charactoceras plicatum* ? (Whiteaves). Lateral view, apparently of the same species as the preceding. East side of Berens island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7159.

Fig. 3. *Garryoceras semiplanatum* (Whiteaves). A, lateral view, with ventral side on right. The lower part of the specimen has been sectioned vertically in a dorso-ventral direction, to show the location of the siphuncle. B, dorsal side of specimen, showing downward curvature of sutures of the septa. C, cross-section of the conch, showing location of the siphuncle. St. Andrews, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1834.

Fig. 4. *Kindleoceras reversatum* Foerste. Cross-section of conch, showing size and location of siphuncle. Clay Cliffs, on eastern margin of Manitoulin island; in the Richmond formation. See also Memoir 138, Geol. Surv. Canada, 227, pl. 42, fig. 2a, b, c (1924). Specimen No. 8582.

Fig. 5. *Murrayoceras murrayi* (Billings). Cross-section of conch, showing location of siphuncle. St. Joseph island, Lake Huron; in the Black River formation. Specimen No. 26584, British Museum of Natural History. See also Catalogue of Fossil Cephalopoda in British Museum. A. H. Foord, 329, figs. 50a, b, c *Murrayoceras murrayi* Foerste, Jour. Sci. Lab. Denison Univ., 21, 312, (1926).

Fig. 6. *Winnipegoceras* sp. Lateral view, with ventral side on left, including living chamber and 2 camerae. Bay between Cat Head and McBeth point; Lake Winnipeg; in the Selkirk member of the Red River formation. Specimen No. 5633.

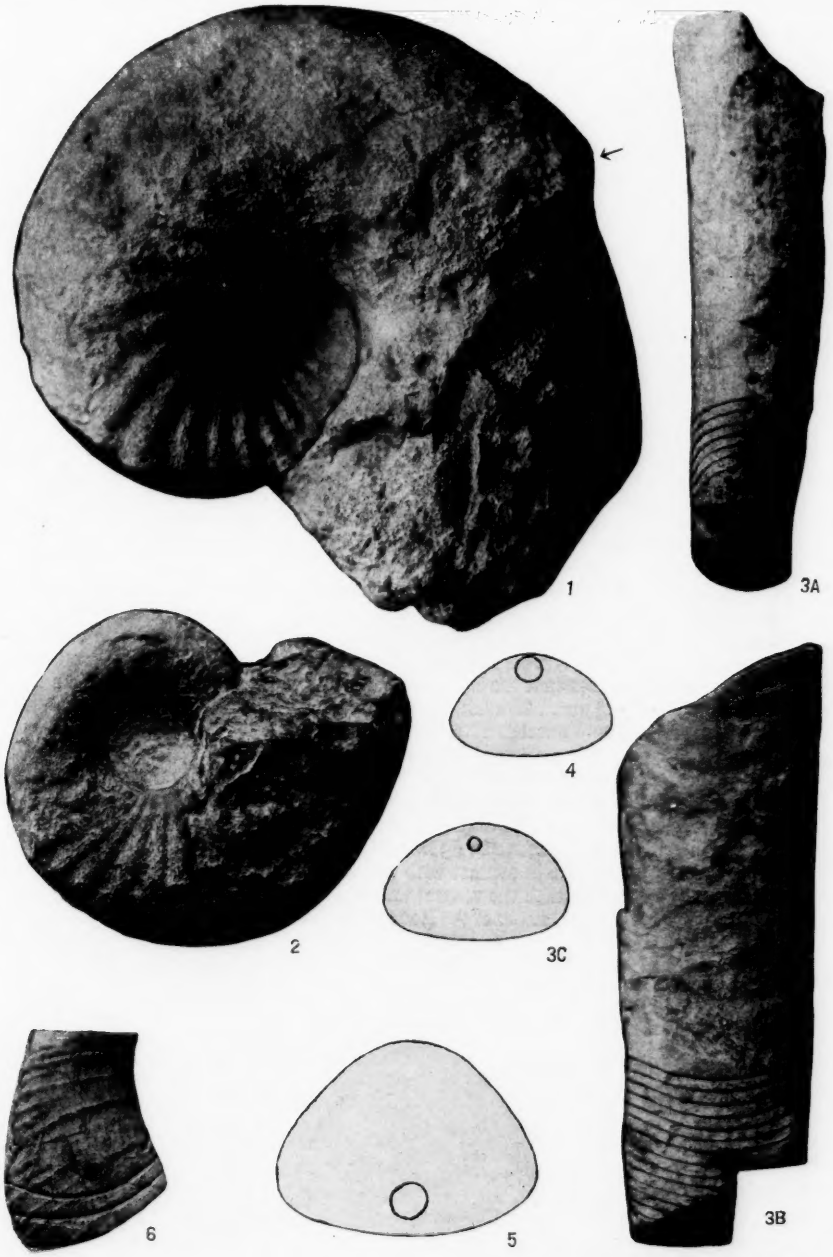

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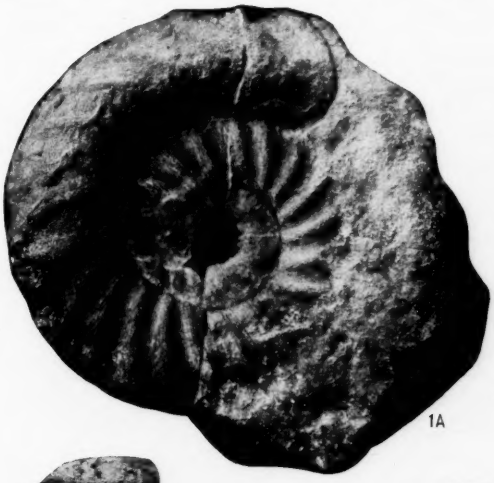
PLATE XVII

Fig. 1. *Discoceras canadense* Whiteaves. A, type; lateral view, apparently showing entire length of living chamber. B, cross-section at top of phragmacone, showing the endogastric location of the siphuncle. Commissioners or Cranberry island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7157.

Fig. 2. *Discoceras canadense* Whiteaves. Lateral view, showing the course of the transverse ribs better than in the type. The location of the base of the living chamber is indicated by the arrow. Swampy island, Lake Winnipeg; in the Dog Head member of the Red River formation. Apparently the same specimen as that recorded by Whiteaves from Little Black island, collected by J. B. Tyrrell in 1889. Specimen No. 7158.

Fig. 3. *Ormoceras lambei* Foerste. Specimen sectioned vertically in a lateral direction so as to show the structure of the siphuncle. This is indicated best by the upper two segments, the lower segments being exposed farther from the center of the siphuncle. This siphuncle is 8 mm. distant from the ventral wall of the conch at a point where the dorso-ventral diameter of the conch is estimated at approximately 48 mm. Tyndall, Manitoba, from the Selkirk member of the Red River formation. Specimen No. 6019. See also plate IX, fig. 3; plate XXVI, fig. 5. The type of this species is illustrated on plate XXXIII, by fig. 2.

Fig. 4. *Cameroceras wilsoni* Foerste. A, lateral view with ventral outline on left. B, lateral view with ventral outline on right. C, dorsal side, facing the interior of the conch. D, cross-section of specimen at fourth annulation from top as seen in fig. C, but oriented as in fig B. Interpreted as an endocone, flattened on its ventral side where in contact with the ventral wall of the siphuncle, the latter being in contact with the ventral wall of the conch. Tyndall, Manitoba; in the upper or Selkirk member of the Red River formation. Specimen No. 6015.

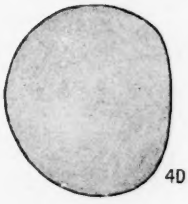

1A

3

4A

1B

4B


4D

2

4C

PLATE XVIII

Fig. 1. *Oxygonioceras* (?) *latum* Foerste. Upper part of a phragmacone with wavy, acute dorsal vertical outline, and with a much more sharply acute ventral outline. The siphuncle is exposed at the points indicated by the two arrows. From some unknown locality in Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7154. See also pl. XIX, fig. 2.

Fig. 2. *Oxygonioceras* (?) *latum* Foerste. Living chamber and adjacent part of phragmacone. Dorsal vertical outline not undulated as in preceding specimen. Ventral outline not preserved. Of the living chamber a height of 60 mm. above the lowest part of the lateral suture at its base is preserved. From some unknown locality in Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7151a.

Both figures are reduced to 0.81 of their natural diameters.

2

1

PLATE XIX

Fig. 1. *Wilsonoceras mccharlesi* (Whiteaves). Lateral view of the type specimen described by Whiteaves under *Trochoceras*, showing half of the outer volution. Of the next inner volution only that part indicated along the upper part of the figure is known definitely, the remainder of this inner volution being the work of the person who attempted to clean the specimen. The figure shows the numerous transverse ribs on the surface of the shell, and the ventro-lateral course of the sutures of the septa. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1873. Figure reduced to 0.72 of the natural diameter. See also plate XX, fig. 1.

Fig. 2. *Oxygonioceras* (?) *latum* Foerste. Cross-section of the type, showing the location of the siphuncle. See also plate XVIII, fig. 1.

Fig. 3. *Ormoceras lambei* Foerste. An attempt to secure an estimate of the relative size and location of the siphuncle within the conch, as based on the specimen illustrated on plate XVII, by fig. 3.

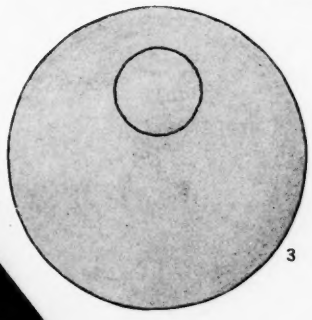


PLATE XX

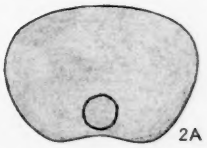
Fig. 1. *Wilsonoceras mccharlesi* (Whiteaves). Ventral view of the same specimen as that represented on plate XIX, by fig. 1. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1873. Figure reduced to 0.72 of natural diameter.

Fig. 2. *Discoceras* sp. A, cross-section, showing location and size of siphuncle. The ventral side is flattened. The lateral sides converge in a dorsad direction. The dorsal impressed zone is distinct but not deep. From the Gasteropod limestone, at Brevig, southwest of Oslo, in Norway. B, dorso-ventral vertical section of ventral side of conch to show structure of siphuncle. The vertical outlines of the segments are slightly concave along the septal necks and slightly inflated along the connecting rings. From the Ringerike area, southwest of Oslo, in Norway, from the same horizon as the preceding, corresponding to the Upper Leptaena limestone of Sweden, and the Lyckholm of Esthonia. The species here figured differs from typical *Discoceras antiquissimum* Eichwald only in its surface ornamentation, the ribs being conspicuous only laterally, becoming less conspicuous ventro-laterally, and almost disappearing ventrally. These ribs also are more numerous than in the genotype, here mentioned.

Fig. 3. *Billingsites troedssoni* Foerste. Cross-section circular at mid-height, but apparently a little depressed toward the aperture. Dorsal saddle very strongly recurved near the center of the lateral sides of the ovoid specimen. Found at Kallholn, in Dalarne; in the Upper Leptaena limestone, at present known as the Kallholn limestone. In the Riksmuseum, at Stockholm, Sweden.

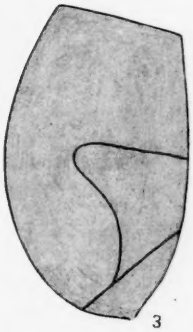
Fig. 4. *Billingsites deforme* (Eichwald). Dorsal side, showing the dorsal saddles. Copied from Eichwald, Lethaea Rossica, pl. 49, fig. 18. From Hohenholm on Dagö island, Esthonia; presumably in the Lyckholm limestone; from erratic blocks.

1



2A

2B



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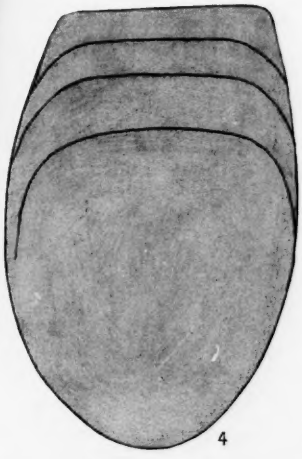

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PLATE XXI

Fig. 1. *Wilsonoceras mccharlesi* (Whiteaves). Type of the specimen described by Whiteaves as *Apsidoceras insigne*, but indistinguishable in the present state of our knowledge from the species described by him as *Trochoceras mccharlesi*. Lateral view of basal part of living chamber and of the adjacent part of the phragcone, showing the sutures of the septa with their slight downward curvature laterally. Stony Mountain, Manitoba; in the Stony Mountain member of the Richmond group. Specimen No. 2217.

Figure reduced to 0.65 of its natural diameter. See also plate XXII, fig. 1.

1

PLATE XXII

Fig. 1. *Wilsonoceras mccharlesi* (Whiteaves). Type of the specimen described by Whiteaves as *Apsidoceras insigne*, but indistinguishable in the present state of our knowledge from the species described by him as *Trochoceras mccharlesi*. Ventral side of specimen illustrated on plate XXI, by fig. 1. Only a little more than half of the width of this side is preserved, but this is sufficient to show the strong downward curvature of the sutures of the septa ventrally. Stony Mountain, Manitoba; in the Stony Mountain member of the Richmond group. Specimen No. 2217. Figure reduced to 0.81 of its natural diameter.

Fig. 2. *Cyclendoceras kindlei* Foerste. Cross-section of conch indicating size and location of siphuncle. Specimen obliquely distorted. See also plate XII, fig. 2.

Fig. 3. *Ephippiorthoceras* cf. *formosum* (Billings). A, cross-section of lower end of specimen, showing size and location of siphuncle. B, vertical lateral section of several camerae, showing form of segments of siphuncle. See also plate XXXVII, figs. 3A, B.

Fig. 4. *Orthoceras* sp. (East Selkirk). A, vertical lateral section, showing form of segments of a siphuncle. B, cross-section of conch, showing size and location of siphuncle. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 6016.

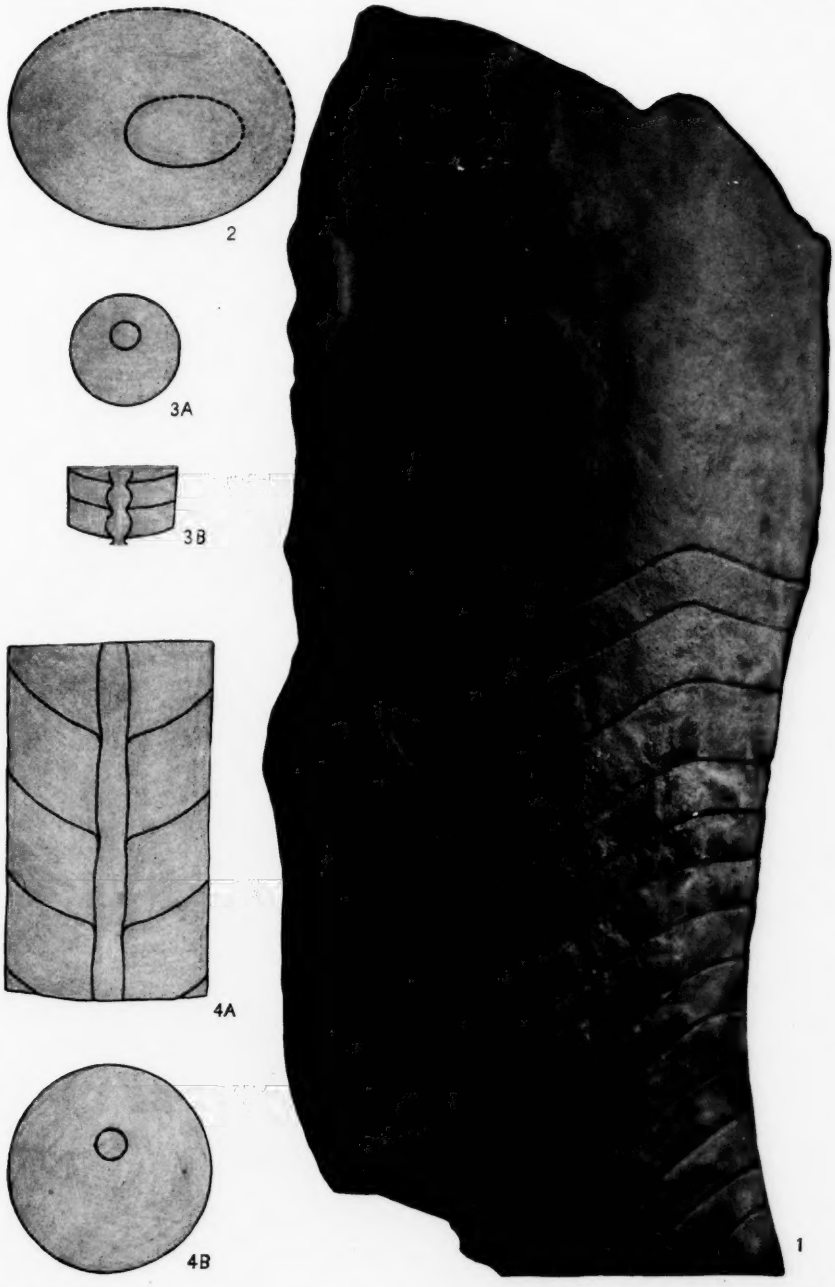

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PLATE XXIII

Fig. 1. *Wilsonoceras mccharlesi* (Whiteaves). Lateral view with the base of the living chamber indicated by a dotted line. Several sutures of the septa are indicated on the right side of the figure and at its base. At the break indicated at the base of the figure the siphuncle is exposed at its passage through one of the septa. Additional traces of segments of the siphuncle are exposed by the adjoining volution immediately above this break. The relatively numerous transverse ribs, curving strongly downward, characteristic of the surface of the shell in this species, and the course of the sutures of the septa ventrally are well exposed between the break at the base of the specimen and that crossing its lower left part, but they do not show in the figure since they were not in focus while producing the photograph. These transverse ribs and sutures are exactly like those shown by the type of the species as illustrated on plates XIX and XX. The downward curvature of the transverse ribs along the ventral side of the conch is well shown between the crack at the base of the specimen and the point indicated by the arrow. Above the level of this arrow the ventral side of the last volution is distinctly flattened for a width of 50 to 75 mm. in a manner suggesting the ventral flattening of the specimen illustrated on plates XXI and XXII, described by Whiteaves as *Apsidoceras insigne*. From Tyndall, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 6018.

1

PLATE XXIV

Fig. 1. *Narthecoceras crassisiphonatum* (Whiteaves). A, exterior of a siphuncle with its ventral side on the right and with its septal necks sloping downward toward the left. The upper margin of these septal necks is vaguely indicated. Their lower margin is less clearly defined. The intermediate connecting rings enlarged but slightly within the camerae. B, vertical dorso-ventral section through the same, with its ventral outline on the left. The interior of this siphuncle is occupied by calcareous deposits which line the walls of the siphuncle and gradually grow upward and inward, leaving a central cavity similar in form to a long funnel. This cavity advances upward with increasing age, and is not an endocone. The lower part of this cavity contains a fragment of an orthoceroid. showing several septa and a part of the length of the siphuncle. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1866. Both figures reduced to 0.95 of natural diameter. See also plate XXV, figs. 1, 2.

1A

1B

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PLATE XXV

Fig. 1. *Narthecoceras crassisiphonatum* (Whiteaves). Vertical dorso-ventral section of a siphuncle, with its ventral margin on the left. The inner walls of this siphuncle are lined with a calcareous deposit, the fibers of which are directed radially inward toward the center of the conch. Within this fibrous calcareous deposit there is an elongated funnel-like central cavity, the walls of which are lined by a calcitic lighter colored deposit from 1 to 3 mm. thick, within which is another calcareous deposit, apparently granular in structure. At the center there is a narrow tube-like cavity suggesting an endosiphuncle. Red River Valley, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1870.

Fig. 2. *Narthecoceras crassisiphonatum* (Whiteaves). Vertical section through a siphuncle, with its ventral side on the left. The fibrous structure of the calcareous deposit extends to the central tube-like cavity, 2 mm in diameter. This cavity is crossed by concave vertical partitions at rhythmic intervals. In earlier stages of growth the fibrous calcareous deposit left a central elongated funnel like cavity, the traces of which, at successive stages of growth, are still visible. Lower Fort Garry, Manitoba; Specimen No. 1867c.

Fig. 3. *Armenoceras* sp. Vertical dorso-ventral section through the lower part of a specimen, showing the size and location of the siphuncle, and also the relative number and slope of its nummuloidal segments. The supposed course of the septa is indicated by a line at the top of the figure. From the west side of the North Arm of Great Slave Lake, Canada, 10 miles north of Red Rock point. Specimen No. 5647.

Same specimen as that described as *Endoceras* sp. in Geol. Surv. Canada. Bull. 44, pl. 14, figs. 1A, B (1926); and Jour. Sci. Lab. Denison Univ., pl. 1, figs. 2A, B (1927).

Fig. 4. *Calhounoceras* cf. *candelabrum* Troedsson. Apparently the ventral side of a siphuncle with segments sloping downward from the ventral toward the dorsal side. From the south end of Snake island; Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7140.

Fig. 5. *Narthecoceras simpsoni* (Billings). Lateral view of a siphuncle, with its ventral outline on the left; showing the length of the septal necks, which slope downward from the ventral toward the dorsal side. The intermediate connecting rings are relatively long and narrow, compared with those of *Narthecoceras crassisiphonatum*. The fibrous calcareous structure filling the interior of this siphuncle almost reaches the center of the specimen. Gull harbour, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 6820.

1

2

3

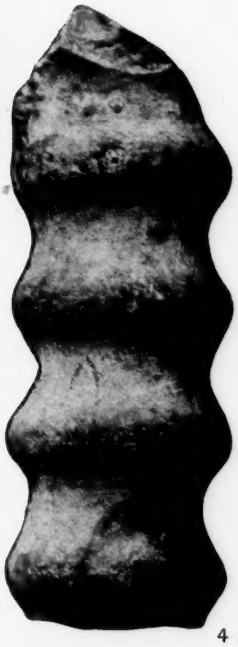

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PLATE XXVI

Fig. 1. *Actinoceras* cf. *bigsbyi* Bronn. Ventral side of a conch exposing the siphuncle along the lower 7 camerae. This siphuncle is almost in contact with the ventral wall of the specimen. The left margin of its lowest segment is outlined distinctly. Some idea of the size of that segment which occupies the eighth camera from the base is given by the outline of its area of contact with the septum at the base of this camera. The remainder of the exposed part of the siphuncle consists of a core of matrix filling an elongate central cavity, tapering in a downward direction. This core is annulated at intervals corresponding to points slightly above mid-height of the camerae, and it is vertically ribbed by lines that have some connection with the vertical lamellae that characterize the calcareous deposits that once lined the inner walls of the siphuncle. In general appearance this specimen resembles that figured by Bigsby in Trans. Geol. Soc. London, ser. 2, 1, 198, pl. 25, fig. 3 (1824), under the name *Orthocerae*, from Thessalon island, Lake Huron. This specimen was identified by Foord, in his Cat. Foss. Cephalopoda in Brit. Mus., 1, 171 (1888), as *Actinoceras beloitense* Whitfield. The specimen here figured was found at Clark point, Lake Winnipeg; in the Dog Head formation. No. 5598. Figure reduced to 0.93 of natural diameter.

Fig. 2. *Whiteavesites winnipegensis* (Whiteaves). Cross-section, showing location of siphuncle slightly dorsad of center of conch. See also pl. XIII, fig. 3; pl. XIV, figs. 1A, B.

Fig. 3. *Paractinoceras canadense* (Whiteaves). A, location and size of siphuncle at top of phragmacone. B, location and size of siphuncle at top of the lower third of the phragmacone; copied from Whiteaves, Trans. Royal Soc. Canada, 9, sec. 4, pl. 10, fig. 1c (1892). See also pl. XIV, fig. 2.

Fig. 4. *Diestoceras whiteavesi* Foerste. Cross-section of conch, showing location of siphuncle. See also plate XXXV, fig. 2.

Fig. 5. *Ormoceras lambei* Foerste. Cross-section of conch, showing size and location of siphuncle, as far as these can be determined from the distorted specimen at hand. See also pl. XVII, fig. 3.

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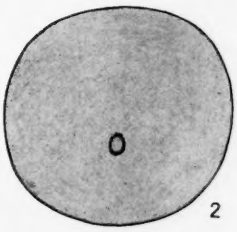

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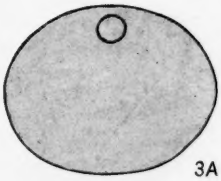
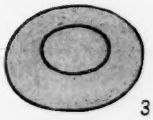


3A



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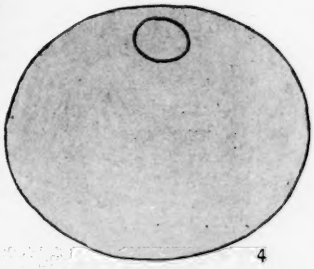

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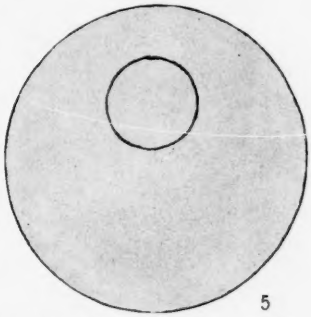

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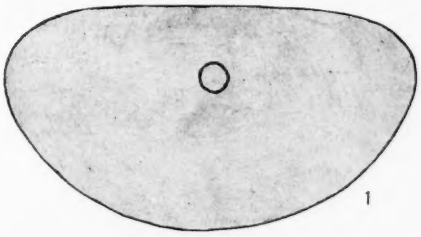
CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXVII

Fig. 1. *Apsidoceras hedstroemi* Foerste. Cross-section of conch, showing location of siphuncle; strongly depressed dorso-ventrally. Sutures of septa curved downward ventrally and laterally as in typical species of *Apsidoceras*. Surface of shell with transverse striae of the banded type, similar to those of *Geisonoceras*. Kallholn, in Dalarne, Sweden; in the upper Leptaena or Kallholn limestone. Preserved in the museum of the Geological Survey at Stockholm, Sweden.

Fig. 2. *Apsidoceras* sp. Cross-section of a specimen similar to that of *Apsidoceras magnificum altum* Foerste (Geol. Surv. Canada, Memoir 154, pl. 39, fig. 1, 1928), from Anticosti island. This Norwegian species attains a diameter of 200 mm. across the umbilical depression. The segments of the siphuncle are nearly globular in form, separated by relatively long septal necks. From Skien and Brevig, southwest of Oslo, Norway; in the Gasteropod limestone, equivalent to the upper Leptaena or Kallholn limestone of Sweden. Paleontological Museum, Oslo, Norway.

Fig. 3. *Kochoceras tyrrelli* Foerste. A, ventral view, B, lateral view, with ventral outline on right. Swampy island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7139. See also plate XXVIII, fig. 1.



1

2

3A

3B

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CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXVIII

Fig. 1. *Kochoceras tyrrelli* Foerste. Vertical dorso-ventral section of a conch with ventral outline on the left, showing segments of the siphuncle appressed against ventral wall of conch, where the septal necks are short or almost absent. Dorsally these segments are nummuloidal in form and are separated by relatively long septal necks. An endosiphuncular tube opens at the base of the specimen on the dorsal side of its lowest point. Swampy island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7139. See also plate XXVII, figs. 3A, B.

Fig. 2. *Kochoceras* cf. *tyrrelli* Foerste. Dorsal side of specimen weathered away so as to expose the segments of the siphuncle. Great Slave Lake, Canada from strata equivalent to the Red River formation. Specimen No. C-2673 in the British Museum of Natural History. Same view as that presented in part by Foord, in Cat. Foss. Cephalopoda, 1, 165, fig. 23 (1888). The opening at the lower end of this specimen is indicated only obscurely in the photograph here presented. Photograph kindly presented by W. D. Long, head keeper of the department of geology in the British Museum. See also plate XXIX, figs. 1A, 1B.

2

1

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CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXIX

Fig. 1. *Kochoceras* cf. *tyrrelli* Foerste. A, ventral view. B, lateral view, with ventral outline on left. The opening at the lower end of the endosiphuncular tube traversing this specimen is indicated on the dorsad side of the lowest point at its base. Only the basal part of the view presented by fig. 1B is included by Foord in his fig. 22–2, on page 165 of his Cat. Foss. Cephalopoda in the British Museum of Natural History (1888). Both figures presented kindly by W. D. Lang, head keeper of the department of geology in the British Museum. Great Slave Lake. See also pl. XXVIII, fig. 2.

1A

1B

AUG. F. FOERSTE

CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXX

Fig. 1. *Kochoceras* cr. *tyrrelli* Foerste. A, ventral view. B, lateral view, with ventral outline on left. Swampy island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7139b.

Camerae relatively more numerous than in the type of the species.

1A

1B

AUG. F. FOERSTE CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXXI

Fig. 1. *Selkirkoceras tyndallense* Foerste. A, lateral view of specimen with ventral outline on left. B, dorsal view of same specimen. C, basal segment viewed from beneath, showing opening of endosiphuncular tube slightly dorsad of its lowest point. D, lateral vertical section through the upper three and a half segments of the siphuncle, with the relative size of the next lower segment also indicated. Tyndall, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 5653.

Fig. 2. *Selkirkoceras cuneatum* Foerste. A, ventral view. Upper part of specimen cut vertically through the center of the siphuncle so as to show its structure, which is similar to that of *Armenoceras*. B, lateral view, with ventral outline on right. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1852.

Same specimen as that figured by Whiteaves under the name *Actinoceras richardsoni*, in Trans. Royal Soc. Canada, 9, pl. 9, figs, 3, 3a (1892). See also pl. XXXIX, fig. 2.

1A

2A

1C

1B

1D

2B

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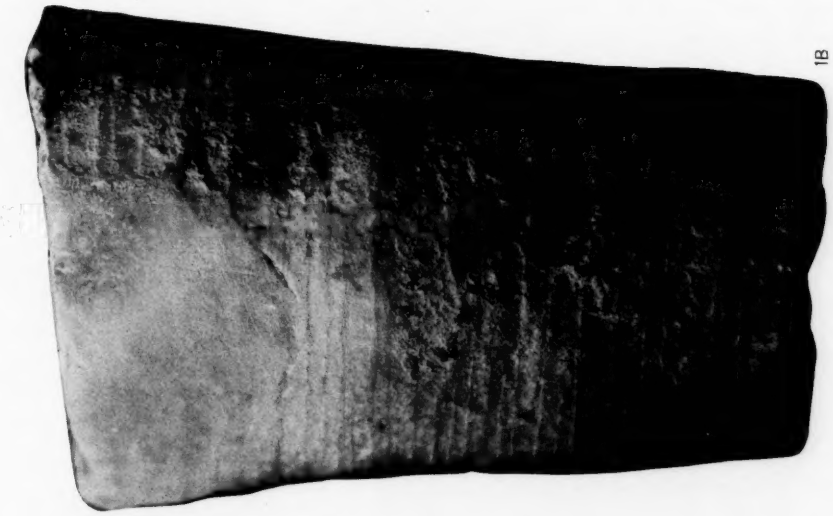
CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXXII

Fig. 1. *Armenoceras richardsoni* (Stokes). A, section through the conch in a lateral direction, exposing the structure of the siphuncle. The distance of the latter from the ventral wall of the conch varies from 6 mm. at the lower end of the specimen to 8 mm. at its top. B, surface of the shell of the same specimen, showing the transverse bands, similar to those of Geisonoceras. Lower Fort Garry, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1854.



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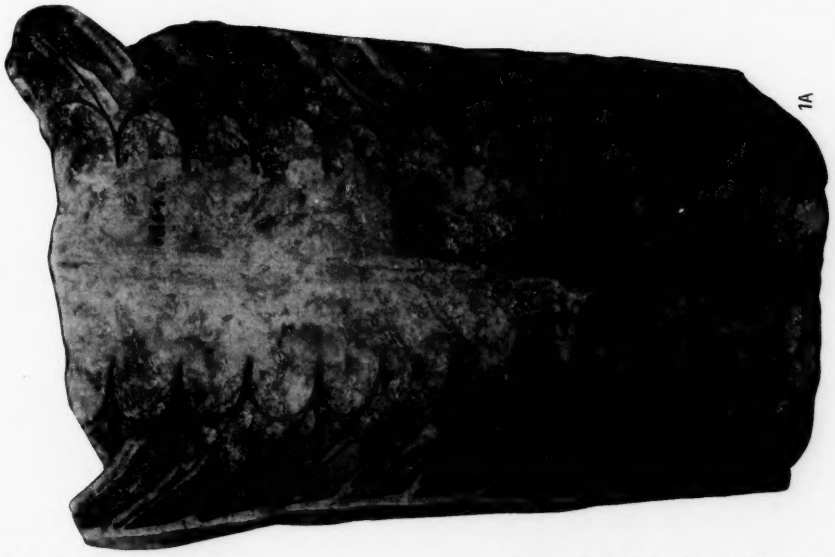


1A

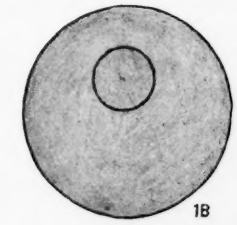
PLATE XXXIII

Fig. 1. *Armenoceras* cf. *allumettense* (Billings). A, vertical section in a lateral direction across the conch, exposing the structure of the siphuncle. B, transverse section of the latter along the upper part of the specimen, showing the relative size and location of the siphuncle. St. Andrews, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1833.

Figure reduced to 0.88 of natural diameter.

Fig. 2. *Ormoceras lambei* Foerste. Specimen weathered on its ventral side so as to expose the siphuncle. The septal necks are short, and the segments of the siphuncle are approximately globular as in typical *Ormoceras*. Black Bear island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 7141.

Figure reduced to 0.90 of natural diameter.



1B

1A

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CEPHALOPODS IN SOUTHERN MANITOBA

PLATE XXXIV

Fig. 1. *Lambeoceras lambii* (Whiteaves). Ventral view, the upper part of the specimen having been cut so as to expose the structure of the siphuncle. Between the points indicated by the arrows there are 6 sutures of septa which curve outward on approaching the lateral margins of the conch. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1872. See also pl. XXXIX, fig. 1.

Figure reduced to 0.72 of natural diameter.

AUG. F. FOERSTE CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXXV

Fig. 1. *Diestoceras* (?) sp. Specimen with base of living chamber indicated by arrow. The margin of the aperture appears to curve inward and downward in a manner which needs explanation. Better preserved specimens are necessary. Black island, Swampy harbour; in the Dog Head member of the Red River formation. Specimen No. 1887a.

Fig. 2. *Diestoceras* (?) *whiteavesi* Foerste. Specimen narrower, with more elongate living chamber; septum at base strongly concave so as to round readily into the lateral vertical outlines of the lower part of the phragmacone. Margin of aperture apparently incurved as in the preceding specimen. Ventral side weathered away so as to expose traces of the siphuncle. More of this siphuncle could be exposed by grinding away that part of the matrix now covering its lower end. Black island, Swampy harbour; in the Dog Head member of the Red River formation. Specimen No. 1887. See also plate XXVI, fig. 4.

Fig. 3. *Diestoceras* cf. *whiteavesi* Foerste. Specimen similar to the preceding, but without any trace of its siphuncle. Dog Head, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1889.

Fig. 4. *Diestoceras gibbosum* Foerste. Living chamber short and rapidly contracting toward the aperture. Location of siphuncle unknown. Tyndall, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 5609.

1 2 3 4

PLATE XXXVI

Fig. 1. *Diestoceras nobile* (Whiteaves). Lateral view, location of siphuncle unknown. Base of living chamber indicated on left. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1885.

1

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PLATE XXXVII

Fig. 1. *Diestoceras apertum* (Whiteaves). Lateral view, location of siphuncle uncertain. Swampy island, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1888.

Fig. 2. *Spyroceras fritzi* Foerste. Lateral view, location of siphuncle uncertain. Structure similar to that of *Spyroceras aquilonare* Troedsson. Ball head, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 6000.

Fig. 3. *Ephippiorthoceras* cf. *formosum* (Billings). A, lateral view, with sutures of septa curving downward laterally. B, dorsal view, with the sutures of the septa curving upward into broad saddles. Tyndall, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 6017. See also plate XXII, figs. 3A, B.

Fig. 4. *Cycloceras selkirkense* (Whiteaves). A, lateral view with ventral outline on left. B, vertical dorso-ventral section showing location and structure of siphuncle. East Selkirk, Manitoba; in the Selkirk member of the Red River formation. Specimen No. 1837.

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CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXXVIII

Fig. 1. *Westonoceras nelsonense* Foerste. Diagonally lateral view, with ventral outline on left where the sutures rise into low angular saddles. Specimen cut at base to expose the structure of the siphuncle. At the second rapid of the Nelson River, going up stream, southwest of Hudson Bay; in the Nelson limestone. Specimen No. 7147.

Fig. 2. *Westonoceras manitobense* (Whiteaves). Specimen cut in a dorso-ventral direction so as to expose the structure of the siphuncle. This is nummuloidal for the upper two segments, but probably a modification of a structure similar to that of fig. 3 in the remaining segments. Bull Head, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 1883.

Fig. 3. *Westonoceras manitobense* (Whiteaves). Vertical dorso-ventral section through the conch to show the structure of the siphuncle. Magnified 2 diameters. Grindstone point, Lake Winnipeg; in the Dog Head member of the Red River formation. Specimen No. 6829.

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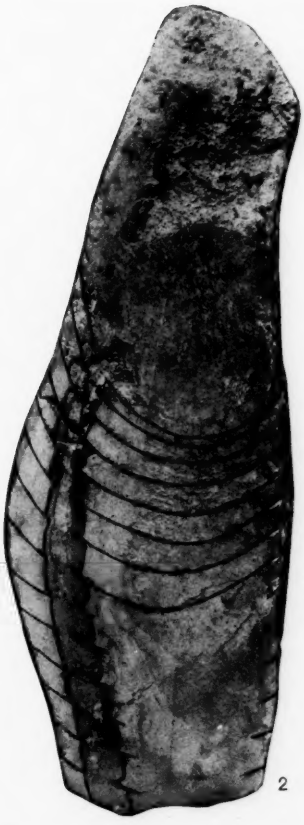

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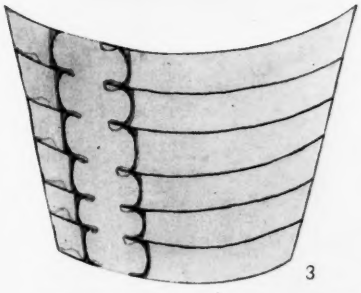

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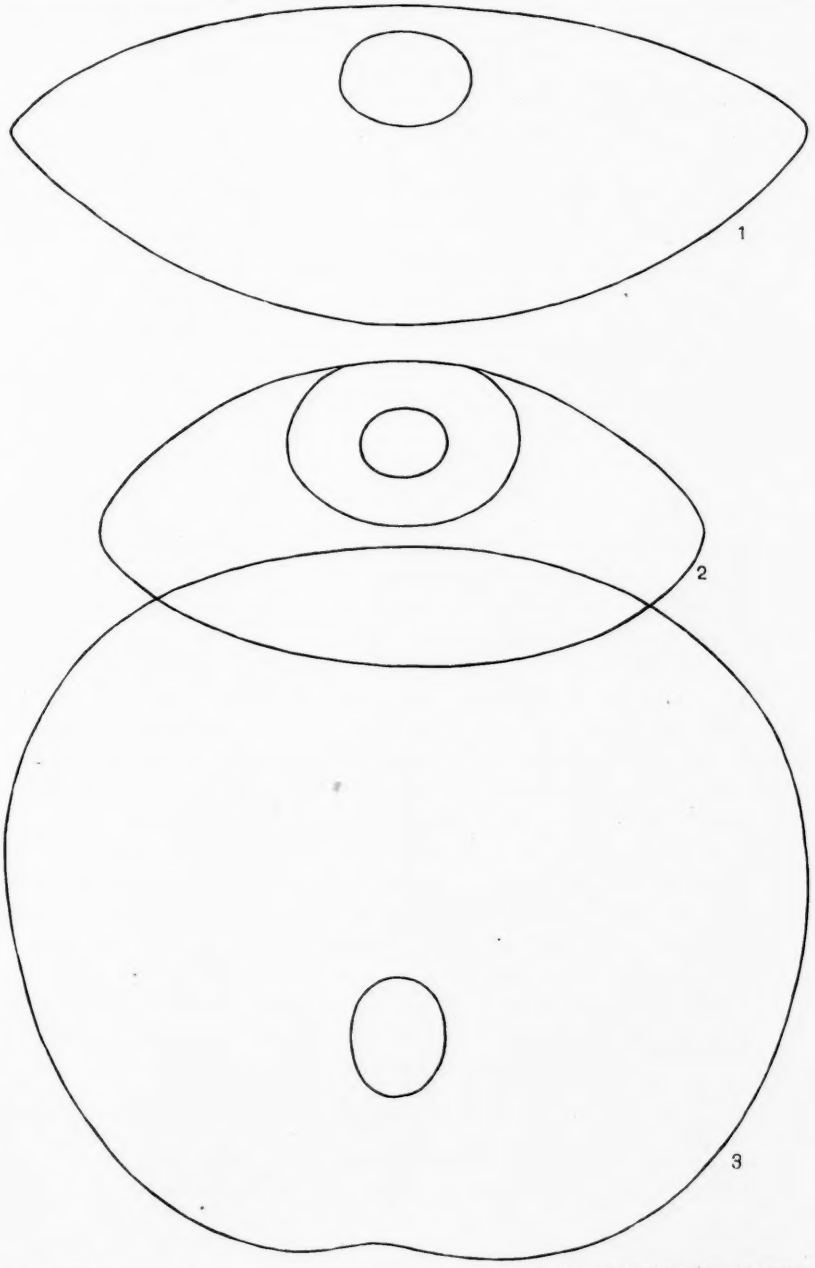
CEPHALOPODS OF SOUTHERN MANITOBA

PLATE XXXIX

Fig. 1. *Lambeoceras lambii* (Whiteaves). Cross-section of conch showing location and size of siphuncle. See also pl. XXXIV, fig. 1.

Fig. 2. *Selkirkoceras cuneatum* Foerste. Cross-section of conch showing location and size of siphuncle. The lower or dorsal side of the figure originally may have been more convex, this side apparently having been flattened by pressure. See also pl. XXXI, fig. 2.

Fig. 3. *Wilsonoceras mccharlesi* (Whiteaves). Cross-section of conch showing location and size of siphuncle. Section taken at the crack shown along the lower part of the conch as oriented on pl. XXIII, fig. 1.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A LARGE FISH SPINE FROM THE PENNSYLVANIAN OF NORTH CENTRAL TEXAS

RAYMOND C. MOORE

Received July 2, 1929, published August 31, 1929

In contrast to the moderately prolific record of piscine life in the Mississippian and Devonian rocks, Pennsylvanian strata in North America have on the whole furnished rather scanty evidence. This is perhaps more true of the ichthyodorulites than of other fish remains. In a few cases, such as at Mazon Creek, Ill., and in nodules from the Lawrence shale at Lawrence, Kan., rather remarkably well preserved fish material is obtained.

To the record of Pennsylvanian vertebrates we may here add description of an unusually large and rather well-preserved, though incomplete, fish spine collected by the writer from the upper part of the Pennsylvanian deposits of north central Texas. The horizon is in the lower part of the Wayland shale, topmost member of the Graham formation, which comprises the lowest part of the Cisco group. This zone is believed to correspond in age with a part of the Upper Douglas or Lower Shawnee groups of Kansas and adjacent parts of the north Mid-Continent region, and probably to the Upper Conemaugh of the Appalachian district.[1] The fish fossil was collected at the same locality, about midway between the towns of Cisco and Eastland in Eastland County, Texas, from which a large and typical assemblage of Wayland shale invertebrates was reported by Plummer and Moore in 1921.[2] A large suite of beautifully preserved bryozoans has recently been described by the writer from this place.[3]

[1] Moore, Raymond C., Correlation of the Pennsylvanian formations of Texas and Oklahoma: Bull. Am. Assn. Petroleum Geologists 13, (1929) (in press).

[2] Plummer, F. B. and Moore, R. C. The Stratigraphy of the Pennsylvanian Formations in North Central Texas: Univ. of Texas Bulletin 2132, 226 (1921), fossil locality 89.1.

[3] Moore, Raymond C. A bryozoan faunule from the Upper Graham formation, Pennsylvanian, of North Central Texas: Jour. Paleontology, 3, 1–27 (1928).

The best collecting is located five miles east of Cisco on the paved Cisco-Eastland road, about 2,000 feet north of the highway where the old road turns due north from the pavement, and in about a quarter of a mile turns due east. The locality is about 1,000 feet north of this eastward turn in the old road.

Genus *Xystracanthus* Leidy

This genus, established on a nearly complete spine discovered by Meek and Hayden in Pennsylvanian (Upper Lansing or Douglas) beds at Leavenworth, Kansas, resembles *Physonemus* McCoy in the direction of curvature of the exserted portion with reference to the inserted part. In the great majority of curved spines the line separating the ornamented, exposed part from the smooth bony structure that was embedded within the body of the fish passes obliquely from a point nearer the proximal end of the spine on the convex side to a point nearer the distal extremity on the concave side. Since the internal part of the spine appears to have projected forward, this means that the external spine had a more or less distinct backward curvature. In *Physonemus* and *Xystracanthus*, on the contrary, the line of contact with the integument crosses the spine obliquely from a point nearer the proximal (inserted) end on the concave side, to one nearer the distal end on the convex margin. Accordingly, if the inserted base had the same relative position as in other spines, the exposed part must have projected upward with a forward curve. This is much more probably true than that the internal structure should be opposite to that of other fishes.

These spines are bilaterally symmetrical and therefore are presumably unpaired. Like *Ctenacanthus* and other similar symmetrical spines they are commonly interpreted as projections from the back of the fish, possibly in some cases serving as the rigid cutwater at the anterior end of the dorsal fin. It has been suggested that they served also as a means of defense. Eastman[4] has advanced the view that the spines of *Physonemus*, with which he places *Xystracanthus*, may have been attached

[4] Eastman, C. R. Fossil fishes in the National Museum, U. S. Nat'l. Mus. Proc., 52, 265 (1917).

immediately behind the head, at the junction with the neck, and that as in recent and fossil chimaeroids they may have served as clasping organs. This is doubtless conceivable in some cases, but it is difficult to correlate the long, laterally flattened internal part of our spine with any part of the body structure in the head region of a fish.

The spines of typical *Physonemus* are short, relatively broad from front to rear, and not uncommonly the exserted part of the spine is smaller than the inserted part. The latter possesses a distinct anterior shoulder that in many examples is very prominent; and denticulate ornamentation of the exposed spine is ordinarily weak or lacking. *Xystracanthus* approaches the slender outlines of *Ctenacanthus*, the borders of the internal part continuing the gentle curves of the external part without development of a shoulder or other abrupt bend. The exposed portion of the spine carries very numerous denticles, that tend to be largest on the anterior concave border and are commonly arranged in more or less distinct longitudinal series. It seems to the writer that basis for the recognition of *Xystracanthus* is entirely adequate; indeed, that there is little resemblance to *Physonemus* except in the forward direction of curvature. As suggested by St. John and Worthen,[5] *Drepanacanthus* has essentially the same characters as *Xystracanthus*, and accordingly may be placed in the synonymy of the latter, which has priority.

Xystracanthus grandis Moore n. sp.

Plate XL, figs. 1–3

Spine large, moderately curved, anterior and posterior margins bending very gently forward and converging slightly toward the apex. The width of the spine from anterior to posterior margins along the base of the external portion of the spine where ornamentation ceases is 130 mm.; the width at the top of the preserved part of the spine (165 mm. nearer the apex) is 90 mm. The total original height of the external portion of the spine thus appears to have been about 280 mm. or perhaps slightly over

[5] St. John, Orestes, and Worthen, A. H., Paleontology of Illinois, 6, 458 (1875).

300 mm. The sides of the spine are broad and nearly flat, sloping very gently toward the narrowly rounded anterior margin, the thickness of the spine near the anterior margin (20 mm.) being approximately two-thirds of that near the posterior margin (31 mm.). The rear margin of the spine is broadly rounded on the lateral margins, but the surface is raised along the median portion of the posterior edge to form an obtusely rounded keel. The medullary cavity is about three times as wide in a direction parallel to the greatest width of the spine as transversely; it is located in the posterior half of the spine, the anterior margin of the cavity being almost exactly midway between the front and rear margins of the spine. Measurements of the cavity at the base of the exserted part of the spine are 50 mm. by 16 mm. Below the line of insertion in the body of the fish only the anterior part of the spine, in front of the pulp cavity, is preserved; the spine is here more compressed laterally and the front margin more sharply rounded.

The line of division between the exposed part of the spine and the internal portion is clearly marked by termination of the superficial denticles and by a slight ridge which crosses the spine at an angle inclined about 60 degrees to the front margin, thus indicating that the spine curves forward into a nearly vertical position above the back of the fish. The external part of the spine is ornamented by very numerous enamel-covered tubercles, which are variable in shape and size but apparently do not exhibit as large variation as reported in some other species assigned to this genus. The largest denticles are disposed along the anterior margin, arranged in somewhat imperfectly defined longitudinal series and making with the progressively smaller denticles on the sides of the spine irregular transverse and diagonal series. The anterior tubercles project farthest (about 3 mm.) from the bony tissue of the spine and with a rather evenly rounded upper surface rise to a sharp crest along the lower margins, so that the denticles as a whole project downward. The largest tubercles have a diameter of about 4.5 mm.; those on the side decrease to 1 mm. or less. Near the base there are approximately 50 longitudinal series of tubercles on each side of

the spine. Along the anterior margin about 16 denticles occur in 80 mm. The inferior portion of the denticles stands nearly at right angles to the surface of the spine. The asymmetrical character of the denticles is most noteworthy in the large tubercles along the anterior margin of the spine, much less so on the sides. The posterior part of the spine is so weathered and abraded that there is no definite indication as to whether it also carries denticles or not. The best preserved of the enameled denticles show a slightly irregularly ridged surface which in some cases on the sides is suggestive of an astraeiform pattern; in other cases the very faint ridges run laterally or are entirely irregular; others of the little teeth are practically smooth.

X. grandis most closely resembles *X. mirabilis* St. John and Worthen. The general appearance and curvature of these species are almost identical, but the convergence of the anterior and posterior margins in *X. mirabilis* is apparently somewhat less than in our form and the anterior denticles are notably larger; the lateral denticles are more definitely arranged in longitudinal series than in *X. grandis*; they are larger and the number of rows is smaller. The slight posterior thickening of the spine shown in *X. grandis* is materially greater than indicated in figures of the species described by St. John and Worthen. Only a very small part of the base below the exserted part of the spine is preserved in *X. mirabilis*, but this indicates that the attitude of the spine is nearly erect as in the case of our specimen. Altogether the resemblance is striking. In *X. acinaciformis* St. John and Worthen from the Middle Pennsylvanian of Dallas County, Iowa, the shape and size of the spine is different, being much smaller and the denticles lack the transverse carina and the suggestion of stellate ornamentation; the spine is apparently much less erect. *X. arcuatus* Leidy from Leavenworth, Kansas, is a relatively narrower and more strongly curved spine with laterally elongated, sharp-crested tubercles. *X. anceps* Newberry and Worthen from the horizon of Coal No. 8 in Illinois is a very much smaller specimen than ours and has denticles which are longitudinally striated. However, so far as can be determined from the rather poor illustrations, it is possible that *X. anceps* is a young specimen of *X. mirabilis* or *X. grandis*.

There is no satisfactory basis for reckoning the size of the shark which bore the large spine found in the Wayland shale. Among acanthodians and plagiostomes in which the fossil remains are sufficiently complete to determine the relation of maximum spine projection to total length of the fish, the ratio appears to range from about 1:8 to 1:11. This suggests that *Xystracanthus grandis* had a length from tip of head to end of tail amounting to at least eight feet and it may have been more than ten feet.

Horizon and locality.—Wayland shale member of the Graham formation, Cisco group, Pennsylvanian. Five miles west of Eastland, Texas.

Xystracanthus striatus Moore n. sp.

Plate XL, figs. 4, 5

The paleontologic collections at the University of Kansas contain a well preserved, though incomplete specimen of *Xystracanthus* that may be described in connection with the account of the much larger Texas species.

Spine gently arched forward, gradually tapering apically, width at base of exserted portion 17 mm., width at top of specimen 13 mm., approximate length of exposed spine 65 to 70 mm. Anterior margin strongly rounded, sides flattened, posterior marked by low keel bordered on each side by a shallow depression; cross section of spine a nearly symmetrical elongate ellipse, thickness 5 to 6 mm. Inserted portion continues smoothly the gentle curvature of the external portion of the spine, but it is more compressed laterally; broadly rounded at base. The line of insertion is very strongly marked; it is inclined at an angle of about 45 degrees to the axis of the spine, which indicates that in spite of the forward curvature the position of the tip of the spine was well behind the front margin at the line of junction with the body. Pulp cavity laterally compressed, elliptical in cross-section, about 5.5 mm. wide by 3.5 mm. thick near base of exposed portion of spine. Its anterior margin is located at the median axis of the spine.

The surface ornamentation above the basal portion consists

of small rounded, enamel-covered tubercles arranged in prominent longitudinal series. Along the anterior margin there is a double row of enlarged tubercles, about 1 mm. in diameter, with gentle slopes on the upper side and steep or vertical slopes on the lower side of a more or less distinct, sharp crest. Otherwise the tubercles are smooth. Near the base there are 9 of these enlarged tubercles in 20 mm. The sides of the spine are ornamented by about 20 longitudinal series of small but prominent denticles, which are spaced on the average about 10 in 10 mm. The perfection of the longitudinal series, emphasized by slight depressions between the rows, is the distinctive feature of the ornamentation, masking effectually a possible alignment of tubercles horizontally or obliquely. These tubercles are smooth and uncarinated.

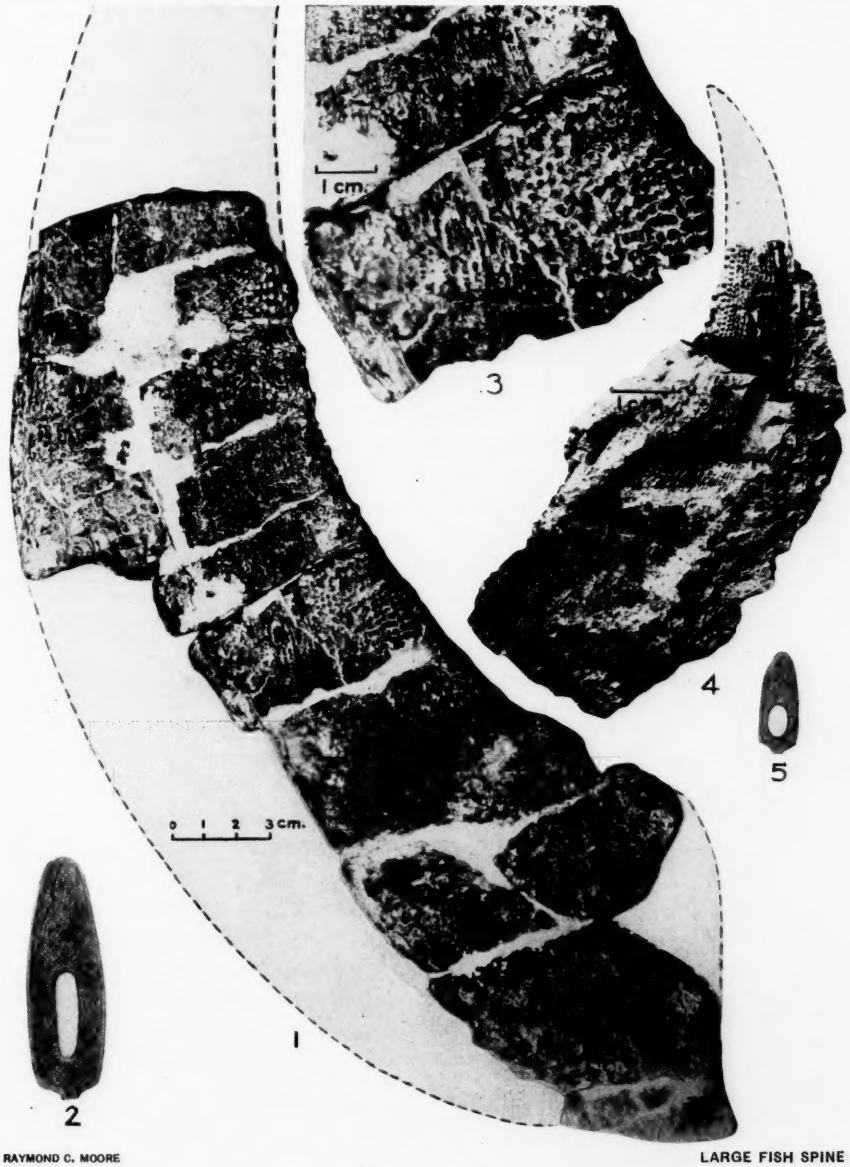
This species is intermediate in characters between *X. acinaciformis* St. John and Worthen and *X. mirabilis* St. John and Worthen. It is about the same in size with the first but proportionately wider; the denticles are much more regularly arranged in longitudinal series and there are two rows instead of a single row of large tubercles along the concave border. *X. mirabilis* is a much more robust species which shows distinctly striated or astraeiform denticles in the longitudinal series on the sides of the spine. *X. anceps* Newberry and Worthen is distinguished by less regular ornamentation and difference in outline of the spine.

Horizon and locality.—Pennsylvanian, eastern Kansas. Univ. Kans. Museum No. 61.

PLATE XL

Figs. 1–3. *Xystracanthus grandis* Moore, n. sp. 1, Right side view of holotype, with partial restoration in outline. The denticles are largely worn away on the side but line of insertion is clearly shown. 2, Cross-section near end of preserved portion of the spine showing elongated medullary cavity and slightly excavated and keeled posterior margin. 3, Portion of spine showing denticles.

Figs. 4, 5. *Xystracanthus striatus* Moore, n. sp. 4, Left side view of the holotype showing prominent longitudinal series of denticles, medullary cavity and impression of internal portion of spine. 5, Cross section near end of preserved portion of spine showing elliptical medullary cavity and outline of margins.



RAYMOND C. MOORE

LARGE FISH SPINE

LOCATION FACTORS IN THE IRON AND STEEL INDUSTRY OF THE BUFFALO DISTRICT, NEW YORK[1]

CHARLES LANGDON WHITE

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Just as human beings differ one from another in certain significant respects, so do iron and steel districts. Never are two precisely alike! In each center of manufacture are characteristic and distinct problems of assembling raw materials and marketing manufactured products,—problems which affect notably the cost of production and the percentage of return on the investment.

Among the several major metallurgical districts in the United States is Buffalo, which attained its position of eminence (fig. 1) because it is excellently located for assembling its iron ore, fuel, and flux easily and economically, and for distributing its manufactured products in the same manner.

BUFFALO'S EXCELLENT LOCATION FOR IRON AND STEEL MANUFACTURE

All things considered, Buffalo's location for manufacturing is probably unsurpassed. Certainly no other American city has so many geographic and economic advantages; rival cities, to be sure, surpass it in one respect or another, but none in the *sum total.* As industries rely more and more upon *scientific researches and surveys* before locating their plants, Buffalo's advantages will become better known. Even now it gains industries as New York City loses them.

Among Buffalo's outstanding advantages are: (1) it lies at the foot of lake navigation where "the lake highway confronts the great land road—gateway to the United States"; (2) it is at the

[1] In this paper the Buffalo District and the Niagara Frontier are considered identical.

mouth of the Buffalo River which affords good wharfage; (3) it is situated upon the New York State Barge Canal, which offers cheap and direct water transport to New York City; (4) it lies

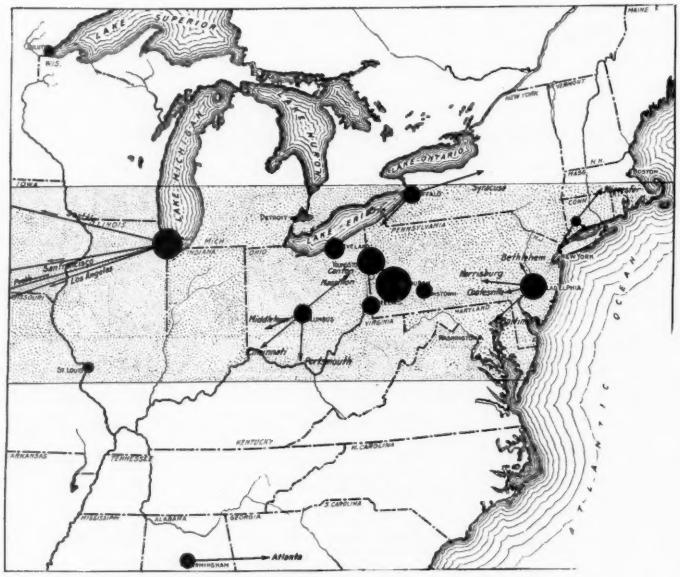

FIG. 1. DISTRIBUTION OF IRON AND STEEL DISTRICTS IN THE EASTERN HALF OF THE UNITED STATES AS GROUPED BY THE FEDERAL TRADE COMMISSION IN THE PITTSBURGH BASING CASE

The size of the circles is proportional to the ingot capacities of the districts. The arrows and accompanying names of cities indicate scattered plants belonging in this particular districting scheme. The area for Chicago is proportional to the ingot capacity of that district, excluding plants in Colorado and on the Pacific Coast, which are indicated by arrows. For the time covered, the end of 1922, Detroit's capacity was too small to show proportionally. The shaded area, representing the zone of densest steel consumption, indicates Buffalo's strategic industrial and commercial situation. (Data from *The Iron Age* and *The Iron Trade Review*.)

favorably with respect to power—both coal and hydro-electric, but especially the latter; (5) it is economically as close to the iron mines of the Lake Superior Region as Chicago or Cleveland, since

the rates to all are identical; (6) it is well located with respect to the labor supply both of the United States and Canada; (7) it lies strategically with respect to great markets—local, New

FIG. 2. PHOTOGRAPH SHOWING SOME OF THE MARVELOUS WATER TRANSPORTATION FEATURES OF BUFFALO

From left to right are Lake Erie, the City Ship Canal, Buffalo River, and the Ohio Basin. At the outbend of the Buffalo River (at right and center of illustration) may be seen a part of the works of the Hanna Furnace Company. (Airview by Airmap Corporation of America, N. Y. Courtesy of Buffalo Chamber of Commerce.)

England, Greater New York, and Canada; (8) it possesses an excellent supply of industrial water; and (9) it has an abundance of cheap flat land for expansion and growth.

BUFFALO'S HARBORS

Since most of the iron ore and limestone and even a portion of the coal arrive by lake carrier, and since considerable tonnages of

both iron in pigs and steel depart by lake vessel and canal barge, a brief treatment of the harbors seems appropriate.

Buffalo, in common with many other lake cities, *e.g.*, Cleveland, has an outer and an inner harbor. The outer one, formed by a breakwater, is four and one-half miles long, 16,000 feet wide, and comprises approximately 680 acres. It is used primarily for anchorage and mooring, but also as a channel for lake steamers entering at the north end and bound for the ore docks or other terminals, and for those entering at the south end and bound for the Buffalo River or inner harbor.

The inner harbor consists essentially of (1) the Buffalo River, for a distance of five miles from the mouth; (2) the City Ship Canal, an artificial ditch two and one-half miles long, paralleling the river at a distance of from 200 to 1,000 feet (fig. 2); (3) the Lehigh Valley Basins, which are connected with the City Ship Canal by a channel 1,400 feet long and 200 feet wide; (4) Black Rock Harbor and Canal, which lies along the Niagara River front for three and one-half miles and is utilized by the large lake carriers en route to Tonawanda and North Tonawanda; (5) the Ohio Basin, the inner harbor terminal of the Barge Canal; (6) the Union Canal; (7) the New York State Barge Canal; (8) the Erie Basin, the principal terminal for the Barge Canal; and (9) the Ore-Ship Channel (Lackawanna). Each accommodates the largest freighters plying the lakes.

LOCATION OF IRON AND STEEL PLANTS

Figure 3 indicates that every company is served direct by lake carriers, in order to benefit from economical transportation both on raw materials and manufactured products.

Three of the five manufacturers (fig. 3)—the Bethlehem Steel Corporation, the Donner Steel Company, Inc., and the Wickwire-Spencer Steel Company—make both iron and steel, and consequently have all their plants in close proximity in order to convert molten pig iron directly into steel, thereby eliminating the cost of reheating iron in pigs. Figure 4 portrays the scientific juxtaposition of blast furnaces and steel mills at Lackawanna,

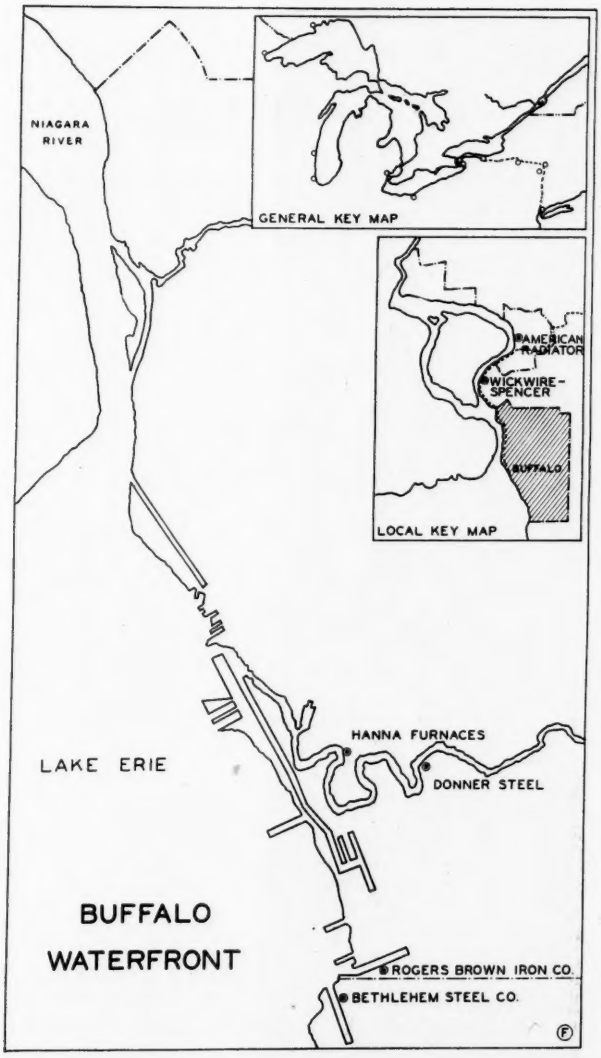

FIG. 3. DISTRIBUTION OF IRON AND STEEL COMPANIES

Water features—rivers and canals—resemble magnets in their ability to draw iron and steel plants to them. Waterside locations are advantageous not only for facilitating transportation, but also for supplying water which is utilized so copiously by this industry.

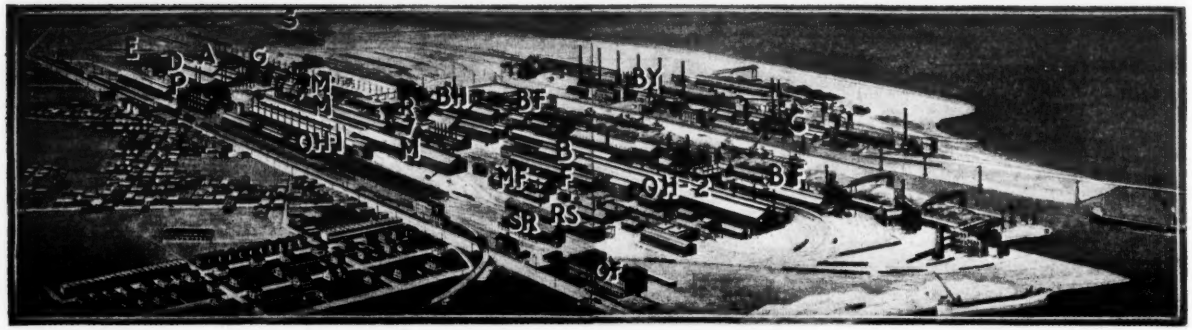

FIG. 4. After spending tens of millions of dollars at Lackawanna, where it owns a thousand acres of land, the Bethlehem Steel Corporation has made it one of the most modern and complete works in the world. A careful study of the distribution of the various units discloses their scientific juxtaposition: note the relation of the coal handling and storage plant to the coke ovens; the blast furnaces to the ore-ship channel and coke plant on the one hand, and to the Bessemer and open-hearth steel mills on the other; and finally the various steel-using units to the steel-making mills.

A, new structural mill; *B*, Bessemer steel works; *BF*, blast furnaces along side ore-ship channel; *BH*, blowing engine house number 3; *BY*, by-product recovery plant (rebuilt); *C*, coke oven plant (largely new); *D*, new 18 inch–14 inch mill; *E*, new shipping yard for finished steel; *F*, foundry; *G*, structural mills; *M*, merchant mills; *MF*, machine and forge shops; *7*, blooming mill number 7 (rebuilt); *OF*, main cffices; *OH1*, open-hearth steel works number 1 (rebuilt); *OH2*, open hearth steel works number 2; *P*, plate mill; *R*, rail mill; *RS*, roll shop; *S*, scrap reclaiming plant (new); *SR*, structural repair shop. (Photo from *The Iron Age*.)

one of the most comprehensive and well balanced plants in the world.

ASSEMBLY OF RAW MATERIALS[2]

Ordinarily it takes about two tons of ore, one ton of coke, and 700 to 900 pounds of limestone[3] to make a ton of pig iron. It is apparent, therefore, that the cost of assembling them is one of the most perplexing and expensive problems confronting the industry: in fact transportation constitutes a tremendous portion of the total laid-down cost of both iron in pigs and steel. It is patent, therefore, that considered solely on the basis of assembly costs, the best location for this industry is one as near as possible to the sources of the raw materials.

Because of Buffalo's relation to the Great Lakes, it assembles its trinity of raw materials at the furnaces more economically than any district using Lake Superior ore, save Cleveland, which has the advantage of greater propinquity to coking fuel.

The assembly of iron ore.[4]—In 1928 Buffalo received from the Lake Superior Region 4,171,819 tons of ore, thereby ranking fourth among Lake Erie ports and sixth among all lower lake ports in ore receipts. But whereas many of its rivals, *e.g.*, Ashtabula, Cleveland, Conneaut, Erie, Fairport, Lorain, and Toledo, trans-shipped to interior points most of theirs, Buffalo trans-shipped only 30,409 tons, reducing the rest, or more than 99 per cent, in local furnaces.

Modern methods are employed in removing the ore from lake vessels and it would be difficult to find anywhere blast furnaces more favorably situated with respect to receiving docks (figs. 4 and 5).

[2] Since the writer considers as *non-geographical* the *processes* of iron and steel making, he does not discuss this aspect of the industry.

[3] The quantity of limestone required varies with the amount and nature of impurities in ore, fuel (coke) and flux (limestone).

[4] Since in another paper the writer has presented in considerable detail the movement of iron ore from the mines to lower lake ports, he will not repeat it in this one. Those desiring more detailed information are referred to White, Langdon, "The Iron and Steel Industry of the Pittsburgh District," *Economic Geography*, April, 1928; or to Hoyt, W. H., "Handling the Nation's Largest Concentrated Traffic," *The Railway Age*, October 9, 1926.

In addition to the millions of tons of ore from the Lake Superior Region, Buffalo is the recipient of several thousand tons of magnetite from the Mineville District in eastern New York.

FIG. 5. AIRPLANE VIEW SHOWING THE STRATEGIC PLANT LOCATIONS OF THE BETHLEHEM STEEL COMPANY AND THE ROGERS-BROWN COMPANY

(Compare with figure 3.) The relation between the plants and the natural environment, particularly the relief and water features, is strikingly visible. Such a location enables these companies to obtain and haul Lake Superior ore via lake carriers direct from upper lake ports to their own docks, and ship their products via lake vessel to Cleveland, Chicago, Detroit, and other lake consuming centers, or via canal barge to New York City for local eastern and foreign markets. (Airview by Airmap Corporation of America, N. Y. Courtesy of Buffalo Chamber of Commerce.)

This local ore has a metallic iron content of about 60 per cent. The greater cost of mining and transporting here than in the lake region prevents large shipments from being made to Buffalo.

The assembly of fuel.—From its inception down to the imme-

diate present, the American metallurgical industry has felt the impelling influence of fuel—first charcoal, then anthracite, and finally coke. Iron ore has invariably moved to fuel. This is consequent upon the fact that coal is bulkier than ore and that "coal fields beget industry and industry consumes steel." Yet this does not mean that furnaces and mills must be located *on* the coal fields; in fact it is better for those depending upon Lake Superior ore to be on the lakes rather than inland on the coal, since an extra rehandling of the ore is thereby avoided. The average assembly cost is greater for ore than for coal, since less of the latter is used in the production of a ton of pig iron.[5]

Buffalo gets some 9,500,000 tons of bituminous coal annually from the northern Appalachian field, though definite data on the tonnage entering into the manufacture of iron and steel are unobtainable. An estimate based upon the district's ingot capacity and production would be in the neighborhood of 4,000,000 tons.

The fuel is delivered mostly by rail via the Buffalo, Rochester, and Pittsburgh; Erie; New York Central (Lake Shore); Nickel Plate; and Pennsylvania Railroads, though an increasing amount is being delivered in lake carriers. For instance, Elkhorn, New River, and Pocahontas coals are taken by rail to Sandusky and then shipped by boat to Buffalo at an appreciable saving in haulage charges over the all-rail route.

The manufacture of coke.—The Lackawanna Company, now owned by the Bethlehem Steel Corporation, is the pioneer among domestic iron and steel makers in the utilization of by-product coke. Because of its great distance from Connellsville, which reigned supreme as the nation's coke center for several decades, Buffalo could not utilize the bee-hive product, since it pulverized in transit. It accordingly installed by-product ovens. The success of this venture was the initial step in the decentralization of the American iron and steel industry. No longer was it shackled to Connellsville; the coke industry forthwith began a migration from the coal mines toward the furnaces, —a migration almost completed now. Whereas in 1912, three-

[5] "Iron in Pigs," *United States Tariff Commission* (Washington), 1927, p. 21.

fourths of the nation's coke was made in bee-hive ovens with the Connellsville Region supplying two-thirds, in 1927 less than one-seventh was so made. There was a decline of 44 per cent in bee-hive output from 1926 to 1927. Ere long Connellsville will be only a memory, for the bee-hive industry is but an auxiliary summoned to furnish requirements only when the by-product plants cannot supply the demand.

More than four-fifths of the country's by-product coke is made in ovens owned by iron and steel companies, and most of the coke and much of the gas is utilized by them. The Lackawanna plant, for instance, uses about 40 per cent of its gas as fuel for heating the ovens, and the remaining 60 per cent for heating the furnaces of the mills, for soaking pits, and for a portion of the rebuilt open-hearth plant. Some of the other companies, however, sell a large portion of their gas to cities for domestic use.

Proximity to water power.—Unlike most major metallurgical districts, Buffalo lies *very close* to Niagara Falls, the best power site on the North American continent. One phase of the six year improvement program of the Bethlehem Steel Corporation, in which it spent about $40,000,000 at the Lackawanna plant alone, was a change from steam and hydraulic power to electric power in the operation of its mills, thus making use of Niagara's cheap power and replacing huge tonnages of coal.

Electric motors used for driving rolling mills, conveyors, and other machinery are exceedingly economical, since they permit the operation of one unit at a time. They increase the flexibility of mill operation and thus save both time and labor.

As coal becomes scarcer and costlier, Buffalo's propinquity to Niagara Falls, a *permanent source of power*, will become more and more significant to the metallurgical industry.

The assembly of limestone.—Buffalo, like other lake districts, secures the bulk of its fluxing stone from the vicinity of Rockport and Calcite on the Michigan shore of Lake Huron, where exists one of the purest deposits in the world.[6] There are also the

[6] Furnacemen use exceeding care in selecting stone; they desire that containing a minimum of clay, since this is a most disturbing element in blast furnace operation.

largest and most modern quarries, the latter almost at the water's edge. Thus the stone is delivered in lake carriers directly from quarry to furnace. An equivalent rail haul, would, of course, be economically prohibitive.

This district gets additional fluxing stone from the vicinity of LeRoy in Genesee County and from Lockport in Niagara County, New York.

BUFFALO'S TRANSPORTATION ADVANTAGES

Transportation is the keystone of economic activity. Professor R. H. Whitbeck has succinctly stated that "The larger the number of advantages possessed by an urban site, the more its growth is stimulated, but good transportation is essential in all cases."[7] Concentrating our attention upon iron and steel cities, we may say that only those places with superior transport facilities gain and retain precedence as *major centers. From a strictly geographical point of view, this industry is concerned with transportation almost in toto, since it is basal at every single stage from the assembly of the raw materials to the distribution of the manufactured products.*

Buffalo was born great in this respect; it is a transportation genius. No other city equals it in the "number and quality of available rail and rail-and-water factory sites."[8]

Lake transportation.—Buffalo ranks fourth among the ports of the United States. Its shipping is excelled among rival lake cities only by Duluth and then solely on the basis of tonnage; based on value of tonnage, Buffalo ranks first.

This distinctive position is consequent upon its location on Lake Erie, at that point where lake navigation both begins and ends. If it were not on the lake, Buffalo would not be an important iron and steel center; it couldn't afford to be. Even with cheap water carriage and the most modern loading and unloading

[7] Whitbeck, R. H., "Selected Cities of the United States," *The Journal of Geography*, September, 1922, p. 207.

[8] Piquet, J. A., "The Strategic Value of Locating Near the Sea," *Industrial Management*, Vol. LXXI, March, 1926, p. 186.

equipment, approximately 42 per cent of the price of its ore represents freight charges.[9]

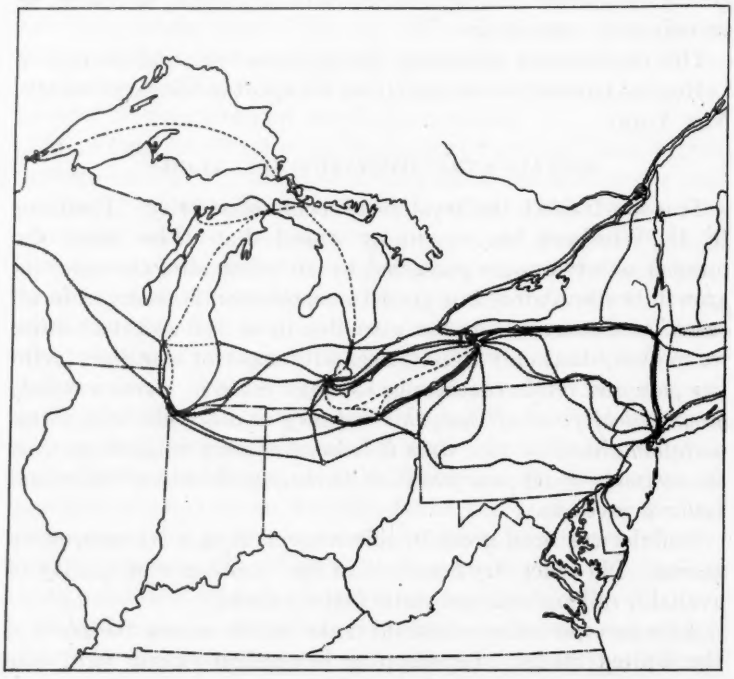

FIG. 6. Buffalo is undeniably a *major* transportation center and this on account of its geographic situation. It has been aptly stated that Buffalo surpasses all other American cities "in the number and quality of available rail and rail-and-water factory sites." The city's incomparable location with reference to transportation via lake, canal and rail is well shown on this map.

This lacustrine location insures economical and efficient assembly and dispensation. The Great Lakes have greatly extended Buffalo's market area, for they have demolished the

[9] The price of standard non-Bessemer ore in 1928 at Buffalo was $4.25. Of this, freight charges were as follows: rail freight from mines to docks 91 cents, lake freight 83 cents, interest and insurance less than 5 cents—total $1.79.

freight rate barriers to the west as determined by the railroads. Consequently Buffalo sells iron and steel as far west as the Twin Cities and Duluth.

Canal transportation.—Formerly those who controlled the metallurgical industry labored diligently and successfully to reduce their costs of manufacture, but they gave comparatively little thought to reducing their costs of distribution. Now, however, many leaders are urging that greater attention be given to the marketing problem as a means of procuring better prices. And one way of effecting this is to utilize inland water-ways.

During the past eight or nine years, rivers and canals have received much attention from iron and steel manufacturers. Birmingham, Buffalo, Pittsburgh, and Wheeling all are sending tremendous tonnages of steel by barge to markets whence they would be barred, if dependent solely upon rail transportation, for the rates are substantially lower than those of parallel competing rail lines.

The Erie Canal, connecting the Hudson River with Lake Erie (fig. 6), contributed notably to the early growth of Buffalo—situated where traffic by the larger lake carriers terminates and where, on account of Niagara Falls, transfer is obligatory from lake vessels to canal barge or railway car.

A detailed discussion of the arguments for and against the New York State Barge Canal would not be possible in this brief paper. Suffice it to say that the canal has been a keen disappointment to advocates of inland water transportation. By many it is dubbed "a white elephant." Nevertheless, the tonnage moving over its waters is increasing steadily, though by no means sensationally. In 1926 only 29,834 tons of pig iron and 9,444 tons of steel billets moved eastward over the canal from Buffalo, whereas in 1928, 122,456 gross tons were shipped, though of this amount about 30,000 tons came from Cleveland. Greater utilization of the canal by the Buffalo metallurgical industry is partly a result of competition from furnaces at Everett, Massachusetts, and Troy and Port Henry, New York, which are making tremendous inroads into the New England market, which Buffalo had come to regard as her own.

That Buffalo intends to make still greater use of the canal is indicated by its acquisition of storage space at New Jersey ports in order to extend, throughout the winter months, the fruits of cheap barge rates. This district strives for a prominent place in supplying the incomparable demands of the Greater New York market.

Transportation via rail.—Since Buffalo lies (1) where it commands the eastern end of the Great Lakes; (2) along the "water level route," the choicest and most accessible breach through the entire Appalachian barrier; (3) at the gateway into Canada, our best foreign customer; (4) in the very heart of the Eastern Railway District of the United States, which, though comprising but 15 per cent of the country's area, nevertheless handles more than half its total railway tonnage; (5) almost midway between Chicago, capital of the great agricultural Middle West, and New York City, capital of the industrial East and gateway to the western world; (6) nearer than other lake ports to Pennsylvania's anthracite region;[10] (7) relatively near the bituminous fields of Pennsylvania, Ohio, and West Virginia; and (8) within a night's ride by rail of half the population of the country, it has become one of the world's outstanding railway centers, being surpassed only by Chicago. There are 1,500 miles of tracks in and around the city. Eleven great lines—the Buffalo, Rochester, and Pittsburgh; Canadian National (Grand Trunk); Delaware, Lackawanna and Western; Erie; Lehigh Valley; Michigan Central; New York Central; Nickel Plate; Pennsylvania; Pere Marquette; and Wabash serve Buffalo, as well as three belt lines and two industrial roads, the latter confined to the inner harbor. The twelve freight terminals receive approximately 45,000 trains annually. Gigantic locomotives, groaning under the stress of tremendous burdens, thunder and roar incessantly in and out of the city, emphasizing the fact that transportation is the city's basic commodity.

Favored by such decidedly superior transport advantages, it

[10] Buffalo handles from 85 to 90 per cent of the anthracite coal which moves via lake carriers to upper lake ports.

is natural that Buffalo should be the country's eighth industrial city and its sixth iron and steel center.[11]

STRATEGIC MARKET LOCATION

An examination of figures 1 and 6 indicates that Buffalo's plants lie in the heart of America's great iron and steel consuming region and are served by one of the finest transportation systems in the world.

Moreover, the Lackawanna plant of the Bethlehem Steel Corporation, which controls about two-thirds of the 2,766,810 tons steel ingot capacity of the district, is a major link in a powerful chain which dominates the markets east of Buffalo and Johnstown. This situation resulted from Bethlehem's adding to its many plants in eastern Pennsylvania (Bethlehem, Coatesville, Lebanon, Reading, and Steelton) the Lackawanna plant at Buffalo and the Maryland plant at Sparrows Point. The far-reaching effects of such a step are obvious.

The local market.—Buffalo supplies almost *in toto* the local market—a significant fact when it is realized that, based on the value of products added by manufacture, Buffalo is a leading industrial center. Though a city of diversified industry, it leans toward the manufacture of heavy commodities, especially iron and steel, on account of transport superiority.

The New York-New England market.—Buffalo is excellently situated for supplying the tremendous markets of the Erie Canal Belt, New England, and New York City, where the railway net is very dense and intricate, where the rail, car, and locomotive requirements are heavy, where the secondary metal-working plants are numerous, and where building and rebuilding are going on incessantly.[12] Moreover, the greater part of this mart is accessible by barge, which effects a saving of from 20 to 25 per cent over the equivalent rail haul.

[11] It is extremely difficult, if not impossible, to obtain reliable and satisfactory statistics on the rank of the several major districts, because there is no homogeneity in the various districting schemes.

[12] New York City is the greatest market in the world for structural steel.

On the other hand, this very market region is most vulnerable to foreign competition, though to be sure, imports are relatively small. From 65 to 90 per cent of the imported iron in pigs, as well as the bulk of the steel, enters the country at eastern seaboard ports between New England and northern Virginia. Most of these imports are consumed in the same area, being unable to penetrate inland in excess of 200 miles, on account of competition with domestic mills.

The Mid-western market.—Buffalo competes with Chicago, Cleveland, Gary, Pittsburgh, and Youngstown for business in the great Middle West. It sends large tonnages both by rail and water, not only to such points as Detroit, Milwaukee, Minneapolis, and St. Paul, where the primary industry is small, but even to Chicago, Cleveland, and Duluth, where it flourishes. One of the largest structural steel contracts (38,000 tons) in the first half of 1928 was placed with the Bethlehem Steel Corporation for fabrication at Buffalo and delivery to Chicago by lake vessel.

The Canadian market.—Canada absorbs about one-half the total steel exports of the United States, which in 1920 amounted to 2,000,000 tons. Obviously, Buffalo, gateway to the dominion, dominates the trade.

The overseas market.—Since the Barge Canal provides an economical means of egress to salt water, Buffalo is one of the better located *interior* districts for reaching overseas markets. Its shipments are, nevertheless, insignificant, as are those of the country as a whole. Whereas we make more than half the world's steel, we are surpassed by Germany, France, Belgium, and the United Kingdom in exports. Our failure to compete is attributable to high assembly costs (our iron ore and coal lie a thousand miles apart, save at Birmingham); to higher delivery costs (our manufactured steel travels on the average 500 miles from fabricating plant to consuming mill); and to higher labor costs, though to be sure this latter inequality is largely nullified by superior equipment and plant layout (fig. 4). On a price basis, America is no match for northwestern Europe; our

great market is at home, while hers is both at home and abroad; she must command a tremendous export trade in order to maintain herself.

COMPOSITION AND COST OF LABOR

Though labor is obviously indispensable in the fabrication of iron and steel, it is not significant in the localization of the industry. Moreover, its cost is but a minor factor in the total cost of manufacture. This is because it is a rule never to have a man perform a task that can be done more effectively and more cheaply by a machine. The development and adoption of the all but human labor-saving devices, which perform most of the operations from the charging of the furnace to the loading of the manufactured products for shipment, were inevitable in the United States, where labor costs are approximately four times those existing in Europe. Hand labor is employed in only the most detailed tasks. It is patent that such a vast and skilful application of machinery is highly advantageous in a country where manual labor is so costly.

Native Americans (including some negroes[13]) and many foreigners are employed, though the latter (Poles and Hungarians) predominate numerically.[14] Since the greater part of the work is unskilled and semi-skilled, it is only natural that it should be done by foreigners, who maintain much lower standards of living than native Americans.

The average hourly earnings of metallurgical workers in all departments are about the same here as in Chicago, Cleveland, and Gary; slightly less than in Pittsburgh and Youngstown; and considerably more than in Sparrows Point and Birmingham. Skilled workers receive approximately the same average hourly earnings in all districts.

[13] Negroes constitute 7.8 per cent of the labor force of approximately 9,000 at the Lackawanna plant and 5 per cent of that of the Wickwire-Spencer plant of about 1,000.

[14] Buffalo has one of the oldest and largest Polish groups in the country, numbering 120,530 in 1920.

BUFFALO NOT CRAMPED FOR ROOM

A self-contained industry,[15] which performs so many different processes in contiguous plants and in single-story buildings (fig. 4), demands immense tracts of flat, cheap land strategically located with respect to rail and water transportation.

Probably no other district surpasses, and few equal, Buffalo in this respect, since it offers "a wide choice of locations purchasable at lower cost than is demanded for inferior locations in other cities."

In respect to available land, Buffalo is antipodal to the Pittsburgh District. The city at the head of the Ohio is characterized by cramped sites, since at first most of the industries were small and huddled close together and thus later had no way to grow; additions and expansions were necessarily made unscientifically. In several instances the manufacturers have been forced to move from the city. Moreover, there are topographical difficulties: Pittsburgh is really a triangle, two sides of which are bounded by the Allegheny and Monongahela Rivers, with slopes which are too steep to build upon, and which rise almost abruptly from the water's edge. Its furnaces and mills are, therefore, strung out along the rivers for miles, where they hug tenaciously the narrow strips of flood plain. The Buffalo District, on the other hand, has plenty of room for the scientific location of new plants and for the expansion of established ones. The Lackawanna plant, for instance, occupies a tract more than a half mile wide and three miles long, constituting 1,000 acres on the shore of Lake Erie, just south of the city line (figs. 3, 4, and 5).

SUPERIOR INDUSTRIAL WATER FACILITIES

Buffalo, in common with its lacustrine kith, has easy access to several sources and to a tremendous supply of fairly pure industrial water. Its proximity to Lake Erie gives it a distinct advan-

[15] Competition is so keen that every possible effort is made to reduce the costs of manufacture. Since there is a marked saving both in fuel and transportation when hot metal is used instead of cold pigs, most steel mills now either adjoin or lie close to the blast furnaces which nurture them; they are then considered "self-contained" plants.

tage over such inland points as Pittsburgh and Youngstown. In these districts, the blast furnaces and steel mills embrace the rivers, whence they draw water, which is both polluted and warm, the latter consequent upon repeated utilization for cooling purposes. Even the plants in Cleveland, despite their proximity to Lake Erie, get their water from the Cuyahoga River, though some is purchased from the city for boiler purposes, since that in the lower river is unfit for such usage.

Buffalo's plants tap not only Lake Erie, but the Niagara River as well. Several of the larger companies have their own systems. The Lackawanna Plant, for instance, pumps from the lake each 24 hours as much as 150,000,000 gallons—an amount as great as that drawn for the whole city of Buffalo.

The companies within the city limits (fig. 3) purchase their water from the city, which offers low rates in comparison with many others—40 cents per 1,000 cubic feet (after the first 6,000 cubic feet per month) as compared with 60 cents at Cleveland and Detroit.

THE PROBABLE FUTURE

This geographical study has indicated the unmistakable importance, in the metallurgical industry, of the *inter-relation of raw materials, markets, and transportation.* If a district or city slips badly in respect of any of these factors, its decline, and perhaps even its eventual elimination, is assured, for competition and small margin of profit[16] make scientific location imperative. Idle furnaces (and there are many scattered throughout the United States) are pathetic mementos of man's erroneous judgment, of altered conditions (*e.g.*, new and changed sources of raw materials), or of both.

Because of the overwhelming importance of the freight factor

[16] The rate of return (about 5 per cent) on the total investment of about 5 billion dollars in the American iron and steel industry is almost the lowest of any of the principal industries. The percentage of return on the total capital of the Bethlehem Steel Corporation was in 1927 and 1928—4.54 and 4.93 respectively, and of the United States Steel Corporation for the same period 5.17 and 6.42 respectively.

in the manufacture of iron and steel and because of Buffalo's superior transport facilities, its future as a major metallurgical center seems assured. The joint remarks of two of the world's most eminent iron and steel figures, Charles M. Schwab and Eugene G. Grace, are of far-reaching significance in this respect:

"The great potential development of the Frontier district was one of the guiding influences in the acquisition by the Bethlehem Steel Corporation of the Lackawanna Company. The confidence we feel in the industrial future of this district is indicated by the fact that the Bethlehem Steel Company has invested nearly $40,000,000 in improvements since acquiring the plant in October, 1922. It may also be regarded as indicative of a growing commercial intercourse for the Niagara Frontier, which, with its strategic location, its ready accessibility to foreign and domestic markets and unlimited water power, possesses an industrial and commercial wealth that is becoming increasingly known to the entire civilized world."[17]

[17] "Industrial Region of the Buffalo and Niagara Frontier," *Buffalo Chamber of Commerce, Industrial Bureau*, p. 2.

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